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A REINFORCED CONCRETE ARCH BRIDGE BUILT IN REINFORCED CONCRETE FORMS WITHOUT CENTERING.

A reinforced concrete arch bridge in which the arches were built without the aid of temporary timber forms and centering is a novelty in bridge engineering which has recently been completed near Belvidere, Ill. Built in forms which were themselves of reinforced concrete, and moreover built without arch centering, this bridge represents a very bold application of a new method of construction. The fact that a heavy proportion of the cost of concrete structures is involved in the temporary forms and supports was discussed at some length in our issue of June 14, 1906, mainly in regard to building construction, and some cases in which this temporary work had been reduced to a minimum were then mentioned, while in our issue of July 12 we described a system of construction in which hollow tile or concrete blocks serve both as the forms and as the permanent facing. The great advantage claimed for the system of bridge construction described below is in the complete elimination of the centering, which, besides being costly, in deep and swift rivers makes construction not only expensive but dangerous. It is true that for the sake of expediency in this particular case a traveler and a temporary trestle were used for erecting the reinforced concrete forms; but the complete method, which it is intended to apply in future work, contemplates the use of a cableway for erecting the voussoirs of the concrete form, so that no falsework whatever will be used.

The bridge in question is a single-track structure carrying the electric interurban line of the Elgin & Belvidere Ry. across the Kishwaukee River, about 2½ miles east of Belvidere, Ill. Fig. 1 is a general view showing the permanent forms for the arch ribs erected ready for the concrete. The bridge has four arches of 81 ft. clear span, with a rise of 10½ ft.; the arches are circular, with a radius of 83.36 ft. on the intrados. At low stages of the river, the water level is about 3 ft. below the springing line, but in extreme flood stages it rises to within 5 ft. of the crown. The arches are of the ribbed type, each span having two arch ribs spaced 8 ft. 10 ins. c. to c.; the ribs are 2½ ft. wide, and vary in depth from 3 ft. at the crown to 4 ft. 6½ ins. at the haunches. These dimensions include the permanent concrete forms described below. Each rib carries a longitudinal 12-in. spandrel wall. The two ribs of each span are connected by eight transverse girders or diaphragms 21 ins. thick, above which are built 12-in. cross walls. The spandrel walls and cross walls support a concrete slab floor. The cross sections in Fig. 2 show this construction very clearly.

The bridge was designed for a live load consisting of a train of 40-ton double-truck interurban electric cars, and has a factor of safety of not less than four in any case. The unit stresses for concrete are 500 lbs. and 50 lbs. per sq. in. for compression and tension, respectively, without temperature allowance; with a temperature variation of 40° F. they are 650 lbs. and 75 lbs., respectively. The unit stresses in steel are 10,000 lbs. per sq. in. without, or 13,000 lbs. with, temperature variation. The moduli of elasticity of the concrete and the steel are in the proportion of 1 to 20: being 1,400,000 lbs. for the former and 28,000,000 lbs. for the latter. It will be noticed that the tension in the concrete is kept below the limit where there is any danger of cracking. The live load stresses were figured for the arch fully loaded and half loaded, and were combined with the dead load and temperature stresses to produce the maximum. The arch rib proper was designed for full strength, no allowance being made for the concrete arch form; this allowance may perhaps be made in later structures, thus reducing the weight and cost. As only the concrete and steel in the core or rib were considered effective, and as the sectional forms actually carry a considerable part of the dead load, the actual factor of safety of the bridge is considerably higher than the nominal factor (four).

The reinforcement in each arch ring consisted of ten ⅞-in. plain round rods in both the ex-

FIG. 1. CONCRETE ARCH BRIDGE FOR THE ELGIN & BELVIDERE ELECTRIC RY.
Strauss Bascule and Concrete Bridge Co., Chicago, Builders.

trados and intrados, with ⅝-in. radial shear rods or stirrups spaced 12 ins. c. to c. at the haunches and 36 ins. at the crown. The ⅞-in. rods were about 30 ft. long and were spliced by overlapping 3 ft. These rods were also continued into the piers and abutments (see Fig. 8). The reinforcement in the spandrel walls consisted of ⅝-in. round rods spaced 12 ins. c. to c., both horizontally and vertically. The reinforcement

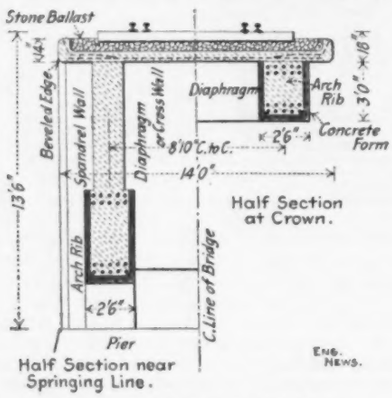


Fig. 2. Cross Section of Bridge.

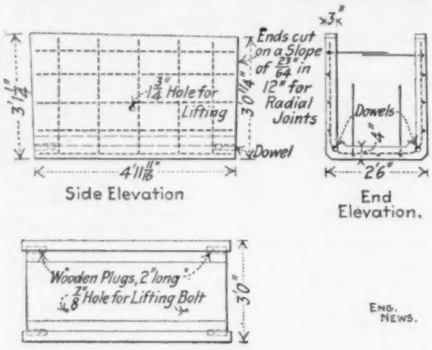


Fig. 3. Voussoir Blocks for Concrete Form for Arch Rib.

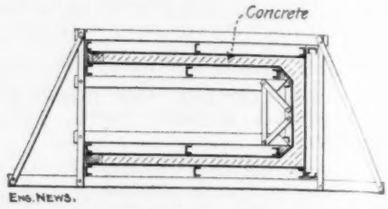


Fig. 4. Steel Mold for Voussoir Blocks of Concrete Form for Arch Rib.

in the floor consisted of transverse ½-in. rods, spaced 5½ ins. c. to c., near the bottom of the slab; alternate rods were bent so as to be near the top in the outer part of the slab and continued up into the curbs at the sides. There were also 12 round rods ⅜-in. diameter placed longitudinally throughout the floor and wired to the transverse rods.

The form for each rib consisted of a series of trough or U-shaped blocks or voussoirs, built of reinforced concrete and made with radial joints, the faces of the joints being inclined $^{29}/_{64}$-in. in 12 ins. These blocks are shown in Fig. 3. The blocks were about 5 ft. long, 36 to 54½ ins. deep and 30 ins. wide over all; they were 3 ins. thick in the sides and 4 ins. at the bottom, so as to have interior dimensions 24 × 32 ins. at the crown and 24 × 50½ ins. at the haunches, corresponding to those of the arch rib. They weighed from 1,500 to 2,200 lbs. each. The blocks were composed of a 1 to 3 mixture of Portland cement and fine crushed gravel, made very wet so as to thoroughly surround the steel reinforcement, which consisted of ⅜-in. plain round rods, the horizontal rods being spaced 8 ins. c. to c. and the vertical rods 12 ins. c to c. Sockets of 1-in. gas pipe in the bottom corners served to hold steel dowels to adjust the adjacent blocks in erection and to hold them in place. Holes in the sides, at about the center of gravity, provided for handling by the crane or traveler, and holes in the bottom were provided for the lifting rods. There were 17 of these blocks to each rib, and when these were erected they formed a self-sustaining hollow arch rib of trough section, to receive the reinforcing-bars and concrete of the rib proper.

These blocks or forms were cast in steel molds, built up of No. 16 sheet steel, stiffened by 3-in. channels and held in alinement by steel angles so connected that the molds could be readily knocked down and reassembled. A section of one of the molds is shown in Fig. 4. The use of the steel plate molds gave a smooth finish to the concrete, but in future work it is proposed to make the interior surface rough, so as to bond with the concrete of the arch rib. There were 136 rib forms and 32 diaphragm forms to be cast, and since each rib was symmetrical about the center, only nine different kinds of sectional forms were required for the ribs and one for the diaphragms. All the blocks were therefore cast in the ten steel molds, the variation in depth of the rib forms being effected by inserting at the proper points wooden stop-off strips between the inner and outer side pieces of the mold. The forms for the arches were cast on their sides, so that one voussoir face was against the working platform on which the mold stood while the other was flush with the top of the mold. For convenience in handling, each sectional form had a hole in each side at about its center of gravity, as already noted. Several of the forms also have two rectangular openings in the inner wall, these being provided for the bonding of the diaphragms with the ribs. All these openings were made by fastening wooden blocks to the molds before the concrete was filled in. The sectional forms hardened very rapidly and it was possible to remove the steel mold 24 hours after the concreting was done. After all the sectional forms had been made, they were numbered and stored at the site until ready to be placed in the structure, being handled in the yard by a derrick.

While this work was in progress, a [illegible] temporary bridge was built by hand-dri[illegible] two rows of piles on either side of the br[illegible] site, capping these with transverse planks, 2 [illegible] ins., and bracing them in both directions [illegible] 1-in. boards. On top of the piles were laid [illegible] 10-in. stringers, upon which rails were spiked [illegible] the traveler.

The method of erecting the ribs was one of the most important and interesting features of the work and is clearly shown in Fig. 5. The erection was carried on from both ends of the span, and in this particular case the concrete forms for both ribs were erected simultaneously; in longer spans, however, each rib would probably be erected independently, so as to reduce the weight handled by the traveler or derrick. Upon each pier (or pier and abutment) of the span to be erected a timber A-frame was set up and anchored back by two 1⅜-in. steel rods, which were made adjustable in length by means of turnbuckles. At the head of the frame was a set of shackles for a number of stay rods. On the temporary trestle ran the erecting traveler (Fig. 6), which had two A-frames outside the line of the ribs and connected by cross timbers and bracing. Two triplex differential hoists operated by hand by endless chains were suspended from these cross timbers and to the hook of each hoist was attached a swing or hoisting beam consisting of a pair of steel channels.

In the erection work the traveler was moved by hand along the trestle to the end of the bridge and picked up one of the form blocks, the hook engaging with a rod passed through the holes in the sides. The block was raised high enough to clear any intervening work and the traveler was then run back to the span under erection, where the form was placed on the working platform of the trestle. The two forms of the two ribs being set on the platform were then connected by two sets of light transverse timber framing, one near each end, so as to be raised and set in place simultaneously. The cross timbers were 4 × 6 ins., connected to both the forms by long bolts as shown in the view, Fig. 7. At the top were U-bolts to receive the hooks of the hoisting

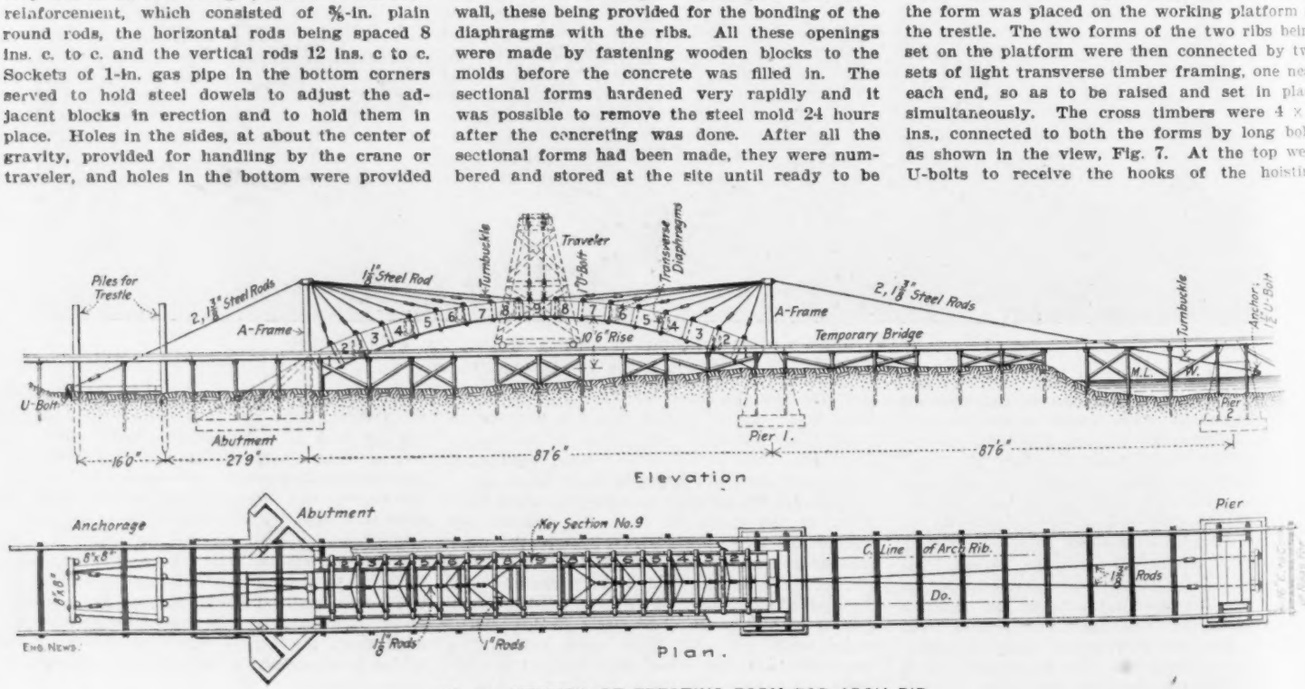


FIG. 5. METHOD OF ERECTING FORM FOR ARCH RIB.

beams. Transverse diagonal bracing was also fitted between the two blocks, and for sections where the diaphragms occurred the transverse forms for these were also set in place, resting upon the bottom cross timbers, so that the arch and diaphragm forms were placed as one unit. The blocks thus temporarily connected were set in place, the proper position being attained by movements of the hoist and traveler, and by fitting the dowels in the bottom of the blocks. While held in position, the shackles at the end of a Y-fork of 1-in. steel rods were connected to lugs held by the 1-in. U-bolts at the ends of the timber framing, the stem of the Y being connected to one of the 1⅛-in. steel stay rods extending from the shackles on the A-frame. The length of this rod had been previously determined, and it was then set up by a turnbuckle to give the exact length to support the voussoir block in its proper position. The radial joints and the dowels in the ends of the blocks ensured accurate adjustment. With 17 sections or blocks to each rib there were eight of these stay rods from each A-frame.

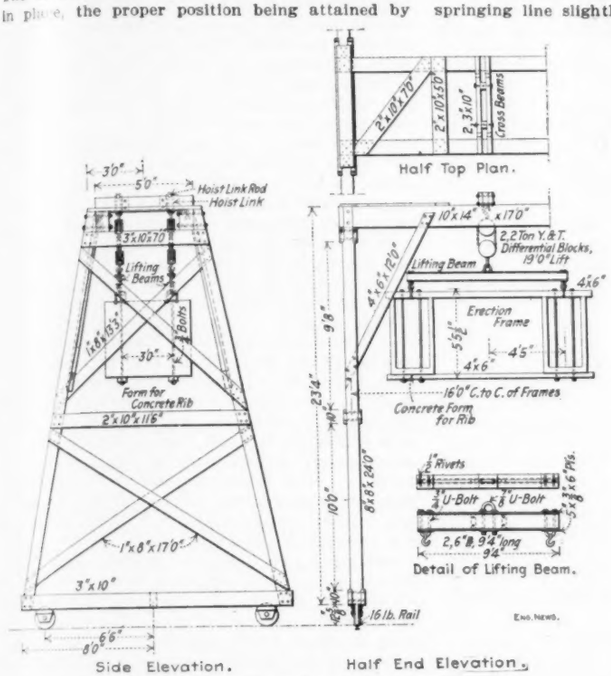


FIG. 6. DETAILS OF TRAVELER.

The erection was begun simultaneously from each haunch, the first sectional form being supported on the skewback at one end, and at the other end attached to the first set of rods from the A-frame, as above explained. The second sectional form was then brought into position and supported at one end against the first form, the other end being supported by the second set of A-frame rods. The connection between the sectional forms was made by means of steel dowels placed in gas pipes located in the bottom corners of the forms, and in some cases by means of wooden blocks fitted to the inside of the forms. In this manner the sectional forms were all placed in position and supported. The keystone required no support other than that supplied by the two adjacent sectional forms, and when this keystone block had been placed the A-frame rods were slackened and the two halves of the arch allowed to close against it. The entire series of sectional forms forming the arch then became self-supporting and the A-frames with their anchors and rods were removed and used for the erection of the next arch in a similar manner. The assumption used in calculating the A-frame rods was that the sectional forms were supported at two points while being placed, and this condition was actually established as explained. The suspension rods were so adjusted that the joints between the various sectional forms were left open slightly at the top.

To insure the proper fitting of the keystone, the faces of the skewbacks on the piers were dressed before erection was started so as to make the angle between the face of the skewback and the horizontal plane through the springing line slightly less than that calculated. In addition, the lower edge of the first sectional form was rounded, so as to keep the pressure from coming too close to the edge, and a strip of sheet lead ⅛ in. thick was placed in the joint. By means of the turnbuckles on the anchor rods, it was possible to raise or lower half of the arch as a unit, the rotation taking place about a horizontal axis near the lower edge of the first sectional form, and the effect was practically the same as if a hinge had been inserted in the joint at the skewback. In this was the opening in the center for the keystone was adjustable, and there was no trouble in fitting the keystone in place. After the removal of the A-frame and supporting rods all the joints were found tightly closed and the alinement was perfect.

After the first arch ring had been completed in this manner, it was left without filling in the concrete until all the remaining arches had been completed. This was necessary, as the intermediate piers would not be stable under the unbalanced horizontal thrust caused by placing the concrete in one span before the skeleton arch of the adjoining span was erected. When the four arches were in place, the steel reinforcing rods were put in position in the hollow ribs. These ribs, together with the diaphragms were then concreted by first putting in a 12-in. layer of concrete and then following up with the remainder. This concrete was a 1-2-3 mixture, and the reinforcement has already been described. The concrete in the arch ring and the diaphragms was made continuous by means of the openings through the inner walls of the sectional forms, the entire construction being thus rendered monolithic. After the arch ring had been completed in this manner the spandrel walls, the cross walls and the floor were built by means of the ordinary wooden forms.

The erection of the arch rings was successfully completed in a short time, notwithstanding the fact that only unskilled labor was employed. It took an average of three days to erect one span and take down and reset the A-frames with their anchorages. The last arch ring was erected in 1½ days and the largest number of sectional forms placed per day was 12 pairs. The entire superstructure, including the arch rings, was completed in 30 days, which included three or four days delay caused by labor troubles.

The substructure presents no features of special interest, but the general design of the piers and abutments is shown in Fig. 8. The three intermediate piers were built of solid concrete, while the abutments were provided with buttressed wing walls, which together with the walls and base slab are all of reinforced concrete. Behind the face wall of each abutment were heavy low buttresses to take the thrust of the arch ribs, and in which the reinforcing rods of the ribs were embedded. With the exception of one pier and one abutment the substructure was founded on gravel. Quicksand was encountered at the two points noted and caused a great deal of trouble and delay. A double-walled cofferdam was finally built around this pier and abutment, and the foundation piles driven inside. The cofferdam was then sealed by depositing concrete under water, after which the construction proceeded in the usual way. The concrete for the piers and abutments was a 1-3-5 mixture.

The floor slab of the bridge is 14 ft. wide and 6 ins. thick, with steel reinforcement as already described. At the edges the thickness was increased to form 8-in. curb walls to retain the ballast, which is 6 ins. deep under the ties, as shown in Fig. 2. There are no parapet walls. Drain holes in the floor are provided at inter-

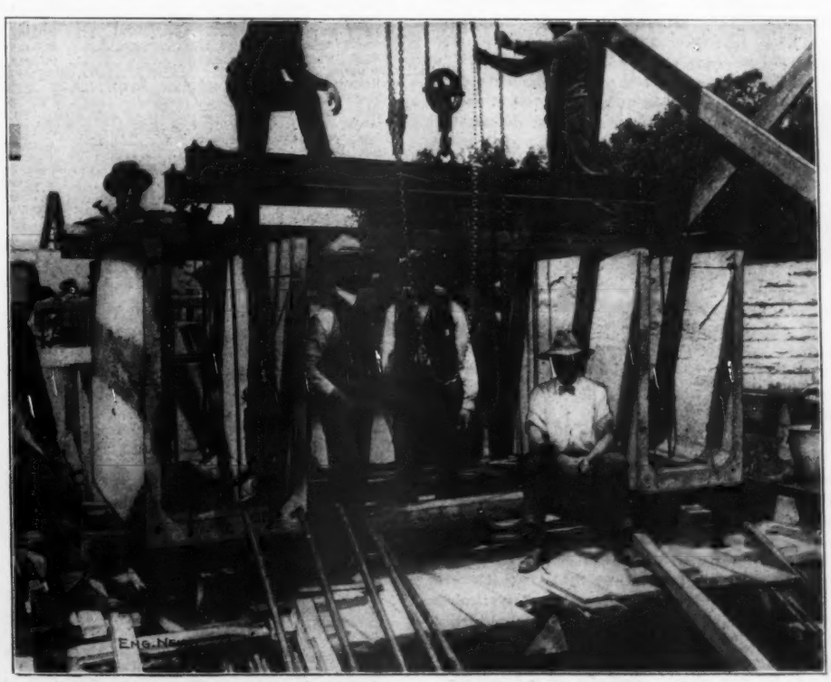


FIG. 7. A PAIR OF VOUSSOIR BLOCKS READY TO BE SET IN POSITION IN THE ARCH FORM.

vals. At each of the piers was a 3-in. pilaster, concealing the expansion joint in the spandrel wall, and having provision for the support of the trolley poles.

The deflection of the arch ribs at the crown was observed as follows: (1) immediately after the erection of the arch-rib forms; (2) after the concrete had been deposited in the ribs; (3) after the spandrel walls and floor of superstructure had been built. The results are shown in the accompanying table.

Span.	Deflection due to concrete. In ribs & diaphragms. ft.	In walls & floor. ft.	Total deflection. ft.
No. 1. North rib.....	0.04	0.02	0.06
No. 1. South rib.....	0.01	0.03	0.04
No. 2. North rib.....	0.09	0.02	0.11
No. 2. South rib.....	0.08	0.02	0.10
No. 3. North rib.....	0.05	00.3	0.08
No. 3. South rib.....	0.04	0.03	0.07
No. 4. North rib.....	0.01	0.04	0.05
No. 4. South rib.....	0.01	0.04	0.05
Average	0.04	0.03	0.07

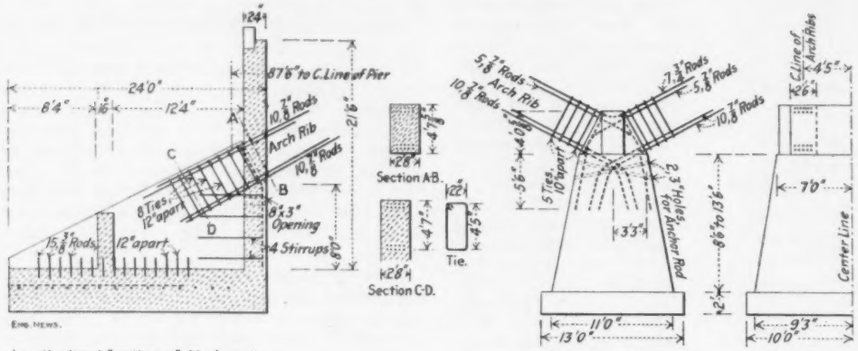
It will be noticed that the deflection caused by the filling of the concrete in the ribs is somewhat variable, which is probably due to the fact that all joints between the sectional forms may not have been closed up completely. After the ribs had been completed, the deflection caused by the additional weight of concrete in the spandrel walls and floor is very regular. The total deflection in no case exceeds the normal, and it is stated that the average elevation of the eight ribs at the intrados of the crown, after the completion of the structure, deviated only 1/100-in. from what had been figured in the office.

The outfit required to construct these bridges involves a large first cost, but after this outfit has once been acquired it enables the construction and erection of the sectional forms at little cost and at considerable speed. The steel molds used at Belvidere will answer for a series of arches ranging in length from 25 ft. to 100 ft., and can be used over and over again. Where there are a series of bridges to build at one time, as for instance on a railway line, this feature is of great importance in reducing the cost. The ribbed type of concrete arch is considered the most economical as regards the quantities of material, and it is stated that with the increased economy of erection made possible by the method here described, the total saving as compared with other forms of reinforced-concrete construction (for the same factor of safety) will be about 30%. It is also to be noticed that this method of construction is applicable to buildings.

In comparing this system of arch construction with the ordinary system in which timber centering is used, it is claimed that in the former case the members carrying the rib adjust themselves automatically and all adjustments occur before the concrete has set, so that cracking will be avoided. On the other hand, when timber centers are struck, the arch may settle suddenly and unevenly, after the concrete has set, thus perhaps developing cracks; this can only be avoided by expensive methods of adjustment. The liability of timber centers to shrink and swell (unless thoroughly seasoned), and the increased cost of timber, are cited as further disadvantages of the ordinary system.

Fig. 9 is a view of the completed bridge and shows the ribs and transverse girders. The projections from the pilasters above the piers are the supports for the trolley poles.

This system of construction was invented and patented by Mr. J. G. Strauss. The Belvidere bridge was designed and built by the Strauss Bascule & Concrete Bridge Co., Fort Dearborn Bldg., Chicago. Mr. K. Hojgaard was engineer for this company, and Mr. George Weston was engineer for the Arnold Co., of Chicago, which company has the general contract for the construction and equipment of the Elgin & Belvidere Electric Ry.



Longitudinal Section of Abutment. End Elevation. Side Elevation.

FIG. 8. DETAILS OF PIERS AND ABUTMENTS.

DUPLEX COMPOUND LOCOMOTIVES of the Mallet system have been built for the Great Northern Ry. by the Baldwin Locomotive Works, and while in general similar to the engine of the Baltimore & Ohio Ry. (Engineering News, June 30, 1904,) they are heavier (but with less weight on the drivers) and differ in some respects from the latter. The Baltimore & Ohio Ry. engine is of the 0-6-6-0 type (with two six-wheel steam trucks), weighs 334,000 lbs., and is used as a pusher engine. The Great Northern Ry. engines are intended for regular freight service, and have pony trucks, so that they are of the 2-6-6-2 type. The Walschaert valve gear and Belpaire firebox are used. The principal dimensions are as follows:

Driving wheels (12)	4 ft. 7 ins.
Wheelbase, each steam truck	10 ft. 0 ins.
Wheelbase, total engine	44 ft. 10 ins.
Wheelbase, engine and tender	73 ft. 2¼ ins.
Weight on drivers	316,000 lbs.
Weight, total engine	355,000 lbs.
Weight, engine and tender	503,000 lbs.
Cylinders, h. p. (2)	21½ × 32 ins.
Cylinders, l. p. (2)	33 × 32 ins.
Boiler, diameter	7 ft. 0 ins.
Steam pressure	200 lbs.
Firebox	117 × 96 ins.
Tubes; No., 441; diameter	2¼ ins.
Tubes, length	21 ft.
Heating surface, tubes	5,433 sq. ft.
Heating surface, total	5,658 sq. ft.
Grate area	78 sq. ft.
Water on tender	8,000 gals.
Coal on tender	13 tons

BRITISH RAILWAY METHODS AND MANAGEMENT WITH SPECIAL REFERENCE TO SAFETY IN OPERATION.

By H. Raynar Wilson*

Before a new railway is constructed in Great Britain, or any widening or extensive alteration is made in an existing line, parliamentary powers have to be obtained to raise the necessary capital and for the compulsory acquisition of the land required. Plans have to be deposited with the government authorities in November, showing what is proposed, and notice served on all owners of property affected, and the county, borough and other authorities.

At the opening of the parliamentary session the bill is referred to a select committee of the House of Lords or House of Commons. It may be introduced into either house first. The committee will hear evidence from the promoters of a new line or the general manager of an existing line as to the purpose of the bill, and from the engineer as to the estimates he submits as to the anticipated cost of the work. Evidence will then be given by others interested in the scheme, and if the bill be opposed on the ground that the line is unnecessary, or that it is competitive with a line that considers it is giving reasonable facilities, then evidence will be furnished by the promoters to anticipate this opposition. Those who oppose the bill will then be heard. Parliament is very jealous over the rights of private persons, public companies and city authorities. If an existing railway company has already a line that serves the public well, Parliament will not sanction a competing line.

Not many new lines are constructed in Great Britain now, as the country is well covered by a network of railways. Feeder railways are being built for the purpose of connecting up villages with a steam road, and these are known as light railways, and regarded more as trolley car lines which may be built after the scheme has been investigated by the Light Railway Commissioners and approved of by the Board of Trade and without parliamentary powers. Cross-country lines are sometimes built under these conditions.

Occasionally the discovery of a new coal field, as happened recently in south Yorkshire, calls for a new line. There may be two or three companies willing and anxious to build such a line. But instead of fighting for possession, as was the case in former years, the companies agree to build a "joint" line, and the South Yorkshire line just referred to is being constructed by four, if not five, different companies, each of which is represented on a joint committee.

The opposition of county and borough corporations may be withdrawn by meeting their wishes or by some conciliation. It is no novel feature for authorities to deliberately oppose meritorious extensions in order to obtain improvements at the expense of the railway, and so levy a mild form of blackmail.

*Care of "The Railway Engineer," 3 Ludgate Circus Buildings, London, England.

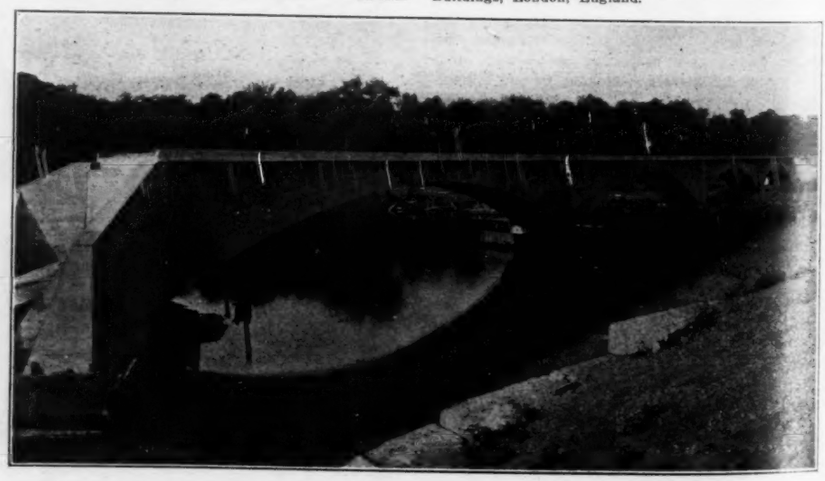


FIG. 9. COMPLETED ARCH BRIDGE FOR THE ELGIN & BELVIDERE ELECTRIC RY.

Should all opposition be withdrawn, the bill is reported as unopposed and the required powers are soon obtained. Should, however, there still be opposition, evidence as to this will be given as just stated, the counsel for the railway company and for the opponents will address the committee, who will then confer in private and subsequently announce their decision, which will be either approval of the bill, approval with modification or rejection. If approved, it has yet another formidable ordeal since if still opposed, it must be considered by a select committee of the other House, where the fight can be renewed. A bill that has passed the Commons committee may meet with a different fate when before a committee of the House of Lords, and vice versa.

If, however, fortune is kind and the company obtains its powers and raises the capital, it may be assumed that the line is constructed. Before it is opened it has to be inspected by the Board of Trade. A month before it is proposed to open the line a notice of such intention is sent to the Board of Trade. Subsequently, there are sent copies of the original parliamentary plans upon which are marked any deviations made therefrom in construction. Drawings, plans and details are given of every portion of the work so that it may be judged whether the line is constructed in accordance with the standard requirements of the Board of Trade.

These requirements call for the highest possible efficiency in every respect. The most perfect form of signaling is demanded, and no difference is made between a main trunk line and a small branch line on which only three or four trains per day are run. The line has to be fenced off by means of approved fencing, or hedging and ditching. Stations are to be provided with over-bridges or subways for passengers to get access from one side to the other. Efficient lighting, naming of stations on signs and platform lamps, and public conveniences are called for. The height of the platforms is specified and the edge has to overhang a certain width to guard against passengers falling between the steps of a car and the edge of the platform.

No crossing of a railway by a public highway at grade is now allowed and certainly no crossing at grade of two railways. Of the latter, there are not more than six or eight examples in the whole United Kingdom. Where road grade crossings exist under parliamentary powers obtained years ago, there is nothing to compel the railway companies to abolish them. They must, however, protect them by efficient gates, interlocked with fixed signals and operated by a gatekeeper. The gates in England are of the five-bar type, covered with netting, swinging horizontally through a quarter of a circle. When across the highway they efficiently shut it off from the railway so that nothing can creep through, and when across the railway access to the tracks is closely barred so that there can be no trespassing. At most public highway crossings a signal tower is provided from which the gates are moved simultaneously by a wheel or lever. The signals for the protection of the crossing are operated therefrom and the gate wheel or lever is interlocked with the levers for the signals, thereby guaranteeing the safety of vehicle traffic.

Foot passengers are shut off from the track by the wickets or smaller gates at the side, controlled by levers in the tower. The gates themselves are provided with large lamps which at night show red along the highway when closed against vehicular traffic, and red along the railway when opened for the highway.

Notwithstanding this care, grade crossings are regarded with a jealous eye. As has already been said, no new ones are authorized, nor are any additional tracks allowed to be laid over them. No switches over which trains switch to and fro are allowed within 300 ft. of a highway crossing. This rule has been provided to guard against vehicle traffic being obstructed needlessly by such switching operations.

Under these restrictions the grade crossings in Great Britain are gradually being eliminated.

Resuming, then, the subject of the construction of new lines: After the plans, drawings, details, etc., have been sent to the Board, an inspecting officer is sent who will walk over the greater part of the line. The clearances of the overhead bridges and tunnels he will prove by means of an open door of a car. The viaducts and bridges will be tested by means of a pair of the heaviest locomotives on the line, which are run across while the deflection under the load is measured. The signal-towers are all visited and the interlocking of every lever examined, the towerman's view of the line and of his signals is ascertained, and also the trainmen's view of signals. Any deficiency will be duly noted, and within a few days official intimation will be received as to whether the line may be opened or not, and what requirements have been omitted. The withholding of permission is a rare event, and the officer will always before leaving intimate his decision and what his requirements are.

These conditions also apply to all widenings and additions or alterations to existing lines, which have similarly to be inspected. Consequently the stability of the railways in the United Kingdom is guaranteed. They have to be constructed of the very best, and that being so, it is an easy matter to keep them up to the original high standard. This furnishes one of the secrets of the immunity from railway accidents in Great Britain.

ROLLING STOCK AND EQUIPMENT.

There is a great difference between American and British rolling stock. British locomotive designers have been crippled by the limited height and width of the openings of tunnels and bridges, and the high platforms. Hence such massive machines as are found on American railways are not possible in Great Britain.

British passenger stock was originally built on the same lines as the old stage coach which the early railways gradually displaced. It ran on two pairs of wheels, and a very large quantity of cars are still of the four-wheel type, but are, of course, larger in size. A middle pair of wheels has been added by most companies, and the cars converted into six-wheel stock. On the main lines the cars are now 60 ft. or more in length, and are carried on a pair of four-wheel or six-wheel trucks, known generally in England as bogies.

All stock is built on the compartment principle and not open as in America. This gives the Britisher the privacy he so much appreciates.

A large number of Pullman sleeping cars and drawing-room cars were to be found on British lines at one time, but they are somewhat rare now. Nearly the whole of the sleeping cars belong to the railway companies and are built on British rolling stock lines. They usually have longitudinal berths, in separate compartments, with lavatory, basin, etc., and folding chair and no upper berths.

Dining cars run on all the principal trains. Separate accommodation is provided for first-class passengers and for second and third class. The food is the same, and often the quantity, but the first-class passenger has more space given him, for which he pays a slightly higher rate for his meals.

Reference under this subject has been made to first, second and third class passengers. It is probably generally known that on British railways there are these class distinctions. More than 90% of the passengers travel third class. The majority of the British companies, and all the Scotch companies, have abandoned second class, but those who retain them only charge about one-fifth more than third class for second class fare.

Practically all passenger stock is now lighted by either electric light or gas (like the Pintsch system). Very few oil lamps are used. Most of the companies, too, have equipped their stock with steam heating apparatus.

Most of the freight cars are of the old-fashioned four-wheel type, and carry about eight gross tons. Larger cars have been, and are being tried, but their general adoption is in the far distant future. There are several reasons for this, one of the chief of which is that to obtain access to the freight warehouses turntables and hoists have to be used, which are only constructed for four-wheel stock. The curves in yards are too sharp for long base vehicles. Again the machinery at the coal pits and for unloading coal into ships has been laid out for the smaller vehicle. Another very weighty reason is to be found in the fact that there are so many freight and mineral cars owned by private individuals and firms. This is particularly true of coal cars, which belong to the proprietors of collieries and to coal merchants. These are known as private owners' wagons, and must not be confused with the private car lines of American railways, as the former are used solely for the traffic of the owner, and perform their return journey empty.

Automatic couplers have not been adopted by British companies, as there is not the call for them that there is in America. The ordinary draw-bar hook and chain coupling can be joined together and uncoupled by means of what is known as a shunting pole. This is a pole carried by the trainmen and switching crew. It has at the end a curved hook whereby the end link of the chain is secured and by resting the pole on the buffers, and, using the latter as a fulcrum, the hook is lifted on to, or off, the draw-bar hook, and there is therefore no necessity for any one to pass between the vehicles to make a coupling.

What is giving much concern to railway men in England is the need for an either-side brake for wagons, i. e., a brake that can be applied by hand from either side of a wagon and can also be released from either side. It would seem to be simple enough to apply the brake from either side, but to be able to take off the brake from one side, when it has been applied from the other appears to be an altogether different proposition.

All locomotives and vehicles conveyed by passenger trains in Great Britain are equipped with continuous brakes, but their use on freight trains has not yet been legally called for, nor is it likely to be for some time. Railway companies, however, recognize that, were their freight trains equipped with continuous brakes, they could travel with safety at greater speed, approach a stopping point with steam on for a longer distance and pull up quicker in case of accident. Some companies are therefore gradually equipping their freight rolling stock with continuous brakes. The brake generally used in Great Britain is the vacuum.

There is very little single-track in Great Britain. The actual figures are not available, but there will not be more than 5% in England, 20% in Scotland and about 40% in Ireland. A considerable mileage of the trunk lines is laid with four lines of track.

In the freight yards are to be found cranes for lifting goods from carts and drays on to the freight cars, capstans (hydraulic and electric) for moving the cars, transfer tables for conveying a car bodily from one track to another, elevators for lifting cars to a higher or lower level, and weighing machines.

The larger portion of the freight traffic in Great Britain consists of small lots, which is one reason why the small freight car will not readily be dispensed with. As it is expensive to send an eight-ton car on a long journey with only a couple of tons in it, some English companies are erecting trans-shipping sheds, to which all the small lots in a certain district are sent, and then all the small lots for one station are put into one, two or three cars, instead of occupying six or eight.

Freight is collected and delivered by the company's own drays, but this does not apply to minerals or timber. The freight rates include this service, but minerals have to be loaded and unloaded by the consignor and consignee.

General freight is conveyed between the large towns by express freight trains, the loading of which is limited. An express freight train may carry, for instance, 40 eight-ton wagons; an ordi-

nary train 60 wagons, whilst the limit of length of a train is 100 empty eight-ton wagons, although at least one company takes 120.

By this means prompt delivery is insured, and freight will generally be delivered within 24 hours of its dispatch. In fact, the companies undertake to deliver goods from London in Dublin or Glasgow the day following their receipt.

STAFF AND DISCIPLINE.

America is a vast country, and everything is in proportion, even to its tragedies. To a foreigner, and a Britisher in particular, there seems to be a lower value placed on human life in America.

All around are to be seen signs of this want of respect for human life. It is to be seen in the streets, where reckless driving abounds, in building and other engineering works, in the slight protection for the public when excavations are being made, and in hundreds of other different phases. On the railway, too, it is to be seen, and here the chief cause, the writer believes, is a lack of discipline. Americans have naturally no respect for their superiors—in fact, they will not admit to having any. Jack, truly, is as good as his master. They chafe at restraint and refuse to be lectured or domineered over. They cannot be driven, but must be left to take their own course in order to achieve the end.

A study of the records of railway accidents in America reveals the fact that there are more mishaps due to failures to obey orders or neglect to carry out instructions than to any other cause.

American railroad companies have endeavored to provide for the safe working of their lines. A committee of the ablest members of the American Railway Association drafted rules to meet all sorts of conditions, and these regulations have been adopted by all the companies. In England they can do, and have done, no more, but the British roads enjoy advantages in that employment is scarce and men therefore value their positions and strive to the best of their ability to keep them. Promotion comes slower, changes are less frequent, and therefore men are accustomed to their duties and the daily routine of events. New men, too, are thoroughly trained and passed as competent by responsible officials before being promoted, and no one is allotted to a post of responsibility—such as that of a towerman—without first being trained in the minor ranks. The state of the labor market gives British companies a large field upon which to draw, and the most suitable men are selected, men of good physique, standard height, of a certain age, with the best of characters, etc. Men who have made frequent changes of employers are avoided, and no man is employed whose testimonials from his masters during the preceding three years (which testimonials the companies obtain direct in reply to their own inquiries) reveal the slightest trace of a lack of honesty or sobriety, or whose reasons for leaving are unsatisfactory. If, to cover up any unsatisfactory service or some period that the man prefers to be unknown, the candidate for employment says he was ill or out of work, this fact must be confirmed by a clergyman, doctor or some other person of position.

The fascinations and attractions of railway work, its privileges in the shape of free and cheap transportation, its continuity of employment, provide British companies with ample candidates so that they have a large range of choice and can select those whose appearance and character go to show a readiness to obey. Soldiers make admirable railway men, as they respond readily to discipline. In England when a man once gets employment on a railway he is loath to leave it. Not only is this due to the privileges of the occupation but to the difficulty of getting work elsewhere owing to the crowded state of the labor market. Consequently resignations are very few. Also owing to a freer method of disciplining men by reprimands, fines, reduction in position or removal to another district, there is not the same need to resort to discharging men as a punishment. The railways support friendly societies, superannuation funds, insurance funds, etc., for the benefit of their employees in sickness, old age and for their families at death. They provide houses and land for gardens at a nominal rent. The consequence is that on British railways there is to be found a steady, staid, reliable set of men who regard themselves as part of the concern, are contented with their surroundings and circumstances and who grow old in the service.

In England the cities and towns are close together and the train service frequent, so that district officers, such as superintendents and inspectors, can keep in close touch with their subordinates, watch their movements and test their abilities.

All the men start at the bottom of the ladder and in a way serve an apprenticeship. The men who become towermen are generally country porters who employ their spare moments in the tower learning the work. Station-masters are promoted from guards and towermen who employ their spare moments in the station office. Guards are first assistant guards, then serve on branch lines before being put in charge of main line trains. In the freight department porters become shunters and are then advanced to the position of guards in charge of freight trains. In the motive power department more start as engine cleaners, then become firemen, then "passed" drivers (i. e., firemen who have passed the driver's examination), then drivers of freight trains and subsequently of passenger trains.

In all grades men have to spend some time before they can qualify for a higher position. This is necessarily so for the reason already given as to opportunity for promotion coming only at rare intervals. Before any man is promoted he is tested in his knowledge of the rules for operation. His writing is again examined, also his hearing and eyesight.

A record is kept of each man's service, particulars are given of his removals and promotions and of the advances in his wages. Details are given of all his offences and whether reprimanded, fined, suspended, reduced in position or how otherwise dealt with.

Trades unions do not play the same prominent part in British railway work as they do in America. The principal society is that of the Amalgamated Railway Servants, whilst the enginemen who are not members of that body belong to an engineman's union, if they belong to a society at all. But universal membership has not yet been arrived at.

British railway men have many privileges. They all belong to a friendly society, insurance or superannuation fund which is supported by the stockholders and which is managed by committee consisting of nominees of the stockholders and of the men. Their pay during sickness is provided for, also for their old age and a payment at death is guaranteed. They have one free pass annually for themselves, their wives and two children, and in addition to this, unlimited transportation at quarter fare for themselves and any members of their families dependent upon them. The companies provide houses for certain of their staff at nominal rents and spaces for gardening by the side of the line. As in America, premiums are awarded for the best kept stations and to section-men who keep their section in good condition. On some lines bonuses are given to those towermen who are not fined during a whole year.

Special care is taken and considerable expense incurred by all the companies so that the men do not work long hours. It must be admitted that this was not always so, and as a result of complaints from the men and frequent comment on long hours worked by some men made by the Board of Trade in their reports on accidents, legislative powers were obtained by the Board of Trade to compel the companies to submit a schedule of the hours of duty of certain men. If the schedule was unsatisfactory the Board called upon the company to submit a better schedule.

Trainmen (drivers, firemen and guards) are instructed that if they see that they cannot complete their journey without working excessive hours, they must apply at the nearest telegraph office for a message to be sent for relief. As the depots are close together and the train service frequent, relief will soon arrive.

Towermen are generally employed on turns of eight hours each and at less busy towers for ten hours and in rare cases for twelve. Trainmen are generally on duty for about twelve hours, but usually have a period of rest during that time.

No one is allowed to commence work again without an adequate amount of rest. From these it will be seen that British companies do their best to avoid excessive hours.

SIGNALING.

All lines in Great Britain over which passenger trains are run are equipped with the block system, and all switches and signals are concentrated and interlocked.

British railway officers early saw the advantages of these safeguards, and most of the lines were equipped, but in 1889 an Act of Parliament was passed compelling the companies to complete the work within 18 months. So much had already been done, however, that less than 20% of the lines required to be equipped.

Absolute blocking is the rule for all classes of trains, and permissive blocking is nowhere used, although in busy stations there is a system employed known as "station yard working" where two trains which have to be joined together or have to make connections are allowed to be in a section at the same time. But the regulations governing such movements are very strict, and the system may not be installed without the consent of the Board of Trade, who have to be furnished with a plan showing the limits within which "station yard working" is proposed.

The rules governing the block system have been drafted by the Rule Book Committee of the Traffic Managers' Conference of the Railway Clearing House.

The code is uniform and has been adopted by all the companies, and there is therefore no divergence in practice on different lines.

All main line switches are coupled to signal towers and interlocked with the signals. In no case are they operated from switch-stands such as are found all over America. No signals are erected or altered until plans showing them have been submitted by the signal engineer to the various officers of the company for approval.

No new signal is brought into use nor any existing signal altered until a notice has been issued. These are contained in a weekly bulletin issued every Friday.

If any work has to be done calling for reduced speed, such as repairs to bridges, track or switch and signal connections, these are named. Should it be necessary to temporarily work all the traffic over one track owing to repairs to the road, it will be stated between what points single track working will be in operation, at what time it will commence and who will act as the pilotman to conduct trains over the track. In case any platform is being repaired and trains have to stop short or proceed further than usual, a notice is issued to that effect, or if any track be shortened for any reason.

Every effort is made to give proper notice to trainmen of such work, and most British officers will postpone any work of which due notice cannot be given.

It must be admitted that all this tends to provide for greater safety and that any labor so spent is well expended.

When it is necessary to divert one track into another for any length of time, as during the repairs to or reconstruction of a bridge or repairs to a tunnel, the additional switches are coupled to a signal tower, or if none be near a temporary one is provided. The customary safety appliances are coupled to the switches and signals are erected.

In case of an accident and the obstruction of one track, so that all traffic has to be carried over one pair of rails, or should this be the case in consequence of repairs to one road, nothing must be done until a pilotman be appointed and

notice served on the towermen at those towers affected. Then no train must be taken onto the single track without being accompanied by the pilotman, or unless he starts the train.

At junctions, trains from converging lines are not allowed to approach simultaneously. One of them has to be kept back at the signal tower in the rear. On busy lines it is necessary often to provide special intermediate towers immediately in the rear of the junction so as to allow trains to approach the junction as closely as possible.

At stations and sidings when a train has been given permission to approach from the tower in the rear, the line on which it will pass is not allowed to be fouled by any switching operations, and should a train be crossed from one main line to another the block instrument for the latter line is made to indicate "train on line," so that no train can be accepted on that line.

All the single track lines in Great Britain are operated on one of three established systems. For the older lines where traffic is light, the old form of train-staff is retained. This is a round piece of wood or brass. It governs one section and no train is allowed to be in a section unless it be in possession of the train-staff for that section, and as there is only one staff there can be only one train, and therefore no risk of collision.

This system has one drawback, as a train can only enter a section at that end where the train-staff is, and consequently there are delays until a train comes from the opposite direction or the staff is sent by hand.

An improved plan was therefore designed which is known as the tablet system. This method of operation requires a pair of electrically-controlled instruments, one at each end of a section in which are placed a supply of tablets, which are metal or fiber disks. Access to these can only be obtained by the consent and concurrent action of the operators at both ends, and the withdrawal of a tablet for a train to go in one direction locks up the instrument at the other end until the tablet that is out is placed in that instrument, or restored to the one it was obtained from. As no train is allowed in a section without a tablet, it follows that only one train can be in a section at the same time. If, however, permissive working has to be resorted to and trains allowed to follow each other, as is the case on many American roads, this can be provided for, but whilst trains can then follow one another, no train can be sent in the opposite direction until all the opposing trains are out of the section.

Another electrically-controlled method where a metal train-staff is used instead of but similarly to the tablet, is also in operation.

The general method of operating single tracks in America is by train orders issued by the train dispatcher. These have long since been abandoned in Great Britain in favor of electrically-controlled systems, and therein lies, no doubt, another secret of the immunity from accident enjoyed there. On American roads these orders are often sent incorrectly, the telegraph operator makes mistakes in reading or copying them or fails to deliver them. Trainmen misread them or forget them or make some error as to the train or trains they have to cross. Often the orders themselves are capable of misconstruction and so mistakes are made and disasters often occur.

Further in the British methods there is a saving in time, as there are no messages to be exchanged with the train dispatcher and no orders to be written out or copied. Again, the trainmen may run in confidence, as the possession of a tablet is a tangible proof that they are in possession of the section.

Automatic signals, used extensively in America, do not meet with favor in Great Britain. This, however, is not due to any want of confidence in the signals, but because, when compared with the ordinary means of signaling by the provision of a tower, towermen and signals, it is found that the latter is cheaper than automatic signals. To understand this it must be remembered that labor is cheap in Great Britain, whilst the signals are dear to install. Further, a towerman can do certain things an automatic signal cannot perform. He can see that the train is complete, that no vehicle is on fire, that no passenger is giving signals of alarm, no load has shifted and that all is in order. He can send word forward as to what class of train is approaching and where it is bound; also he can inform the trainmen, in case of necessity, why they are being detained. Lastly, he can, if necessary, side-track a train for a more important one to pass. These are some of the reasons that have led to a conservative policy towards automatic signals in Great Britain, and the fact that the lines are already equipped with signal towers and signals has greatly contributed towards this. For lines like the Metropolitan District, recently converted from steam to electricity, such a system of signaling is admirably suited.

An American institution in signaling which has found greater favor and which will be adopted more and more is the use of power for the operation of switches and signals. Signal towers in Great Britain have grown more and more in length, and it is difficult to find room in which they can be placed. Especially is this the case in busy places where generally land is the more difficult to obtain. In connection with this it must be remembered that the site for a signal tower must be within a certain radius so as to be in the center of its work, and also for the towerman to be able to see all his work. By the use of power less room is required, as all that is necessary to operate a pair of switches is a small handle or lever, and these levers are less than two inches apart, instead of big levers requiring a space of five or six inches. The towers may, therefore, be considerably shorter and narrower. They may also be placed in otherwise inaccessible places, as there are no rods or signal wires. Concessions as to the distances switches may be from towers are also made by the Board of Trade for power-operated towers, and this may lead to an economy in the number of towers or greater freedom in the laying-out of the engineering work.

Telephones are freely provided between British signal-towers by which the movements of trains are much facilitated, but no block-signals or any signals as to train operations are allowed to be sent by telephone. These must all be sent on the block instruments.

The train-despatcher is unknown on British railways. Such an officer would be a valuable aid at times for regulating the movement of trains, especially when they, or other trains, were late or running out of course. At the present time the towermen have to take the responsibility of deciding whether or not to hold back a train, and frequently they side-track a train needlessly, or go to the other extreme and let it proceed, causing delay to a following and more important train.

ACCIDENTS.

The immunity from railway accidents in Great Britain has become proverbial. The year 1905 has been unfortunate, as up to the time of writing (October) there had been three serious accidents. One occurred in January, when a driver over-ran several signals during fog owing to fog-signalmen not being at their posts. This caused a collision and derailment and led to seven deaths. An unfortunate error was made in August by a towerman who, because the line was set for a side-track and he could not lower his signals owing to the interlocking, presumed the signals were out of order, so he called a train past the signals with a green flag. Consequently the train went on to the side-track and came into collision with another train, causing 20 deaths. On Sept. 1 an express train was derailed owing to some cause as yet unexplained, causing 10 deaths.

These mishaps will spoil the high record enjoyed for many years. For instance, in 1904 there were six passengers and seven employees killed in railway accidents.

The recital just given of how British railways are constructed, maintained and operated will readily account for these figures.

The closer relations that exist between the public and the servants of the companies and between the servants and the officers and the officers and directors must tend for good, while the personal interest taken by an active directorate is bound to have an elevating effect which is further increased by the frequent inspections of the line, stations, yards, etc., by the officers and directors.

The extreme care that is taken in the appointment and promotion of staff, and more continuous employment in one position and less change in personnel and occupation, lead to men making fewer mistakes and being more ready to do the correct thing in a moment of danger, whilst a greater respect for authority makes the Britisher more cautious and more amenable to rules and orders.

The use of the block system on every mile of passenger track and the concentration and interlocking of all points and signals have greatly diminished the number of accidents on British railways. It may here be remarked that these safety appliances have led to similar good results on continental lines. No sort of argument can have weight with the Board of Trade with a view to any relaxation of these rules. In fact, no British railway officer would dream of suggesting such a thing.

Uniformity and standardization of the block and signal systems and the adoption of standard rules for operation by all the companies have contributed in no small measure to the security of British roads.

The law in England allows unauthorized persons found walking on the line to be prosecuted for trespassing, and so one of the causes for the large death roll in America is removed (out of 10,046 persons killed on American railways during the year ending June 30, 1904, 5,105—or more than one-half—were trespassers). Neither do trains travel through the streets in Great Britain, nor do tramps avail themselves of passing freight trains to steal a ride.

What has had a good effect on British railways and tended to keep up a high standard of excellence in construction and maintenance and a close supervision over the staff, is that all accidents and personal injuries have to be reported to the Board of Trade. This not only applies to all derailments and collisions, but all failures of rolling stock.

The causes of all train accidents are inquired into by officers of the Board of Trade. If the facts are clear and do not show any want of administration or weak or deficient rules for operation, no inquiry may be held (providing there were no injuries to passengers). If, however, there are grounds for holding an inquiry it is done. The inspecting officer visits the scene of the accident and looks at the surroundings. He will be furnished by the company with a plan giving particulars of the signal towers, signals, etc., affected, and in the case of a derailment, of the marks on the rails, the spot where the first vehicle left the track and the position in which the train came to rest. He will take the evidence of all concerned and in due time will publish his report, which gives a description of the place, the trains concerned, the results of the mishap, the evidence, a summary of the latter and will wind up with his conclusions and recommendations as to what should be done to avoid future mishaps of a similar nature. It was the continued references in these reports to the need for the block system, interlocking of switches and signals, continuous brakes and excessive hours of duty that led to legislative action being taken with regard to these matters.

These reports are supplied to the press, who copy the conclusions and comment upon them, and this, of course, the companies do not like, and therefore are, from this further cause, more determined to avoid all possibility of mishap. It should, however, here be said that the relations between the Board of Trade and British railways are of the best. The companies never attempt to conceal anything, but render all possible as-

sistance to the officer, whose investigation and report is always impartial.

Any slight accident to a passenger or private individual on railway property that is not caused by the movement of trains has to be reported to the Board of Trade, and when the following figures from the report for 1904 are considered it will be seen that the favorable figures published (favorable when compared with American figures) show a still higher standard:

	Killed.	Injured.
While ascending or descending steps at stations	2	301
By being struck by barrows, by falling over packages, etc., on station platforms	..	119
From falling off platform onto the track	4	135
By other accidents	6	283

All injuries to employees, whether in the movement of trains or not, which necessitate their absence from duty for more than four hours, have also to be reported. During 1904 there were 32 employees killed and 10,640 injured in other work than train movements. But that most of these were due to a want of care or were trivial in their effect may be judged from the following extract:

	Injured.
By stumbling when walking on the line	736
When attending to engines at rest	1,422
From falling off or when getting off or on engines or vehicles at rest	914

The Board of Trade has two assistants inspecting officers and three sub-inspectors who inquire into all serious accidents to employees, and that a large number of the 10,460 cases of injury just referred to were not of a serious nature is proved by the fact that there were only 717 such inquiries held.

These figures surely show that the companies in Great Britain exercise care to avoid accidents and that the men generally are obedient to regulation and do not, as a rule, run risks.

Still the British government was not satisfied as to the care taken by the companies for the safety of their employees, and in 1900 passed a "railway employment (prevention of accidents) act." As the "regulation of railways" act of 1889 met the frequent recommendations of the inspecting officers as to the block system, interlocking, etc., so this act of 1900 met the constant comments of the assistant and sub-inspectors as to the causes for mishaps to employees. One cause was that cars were only labelled as to destination on one side and consequently trainmen had to pass under or between the cars when the label was on the opposite side. Men were killed and injured owing to having to work in darkness or semi-darkness, and one of the remedies sought was for the better lighting of stations and yards. Men fell over exposed point rods, lever stands, signal wires, and these were to be lowered to below the ballast level or boxed in. Enginemen were injured owing to the boiler gage glasses bursting and in getting over the coal to the tool-boxes, which were at the far end of the tender, or to see how much water they had. These mishaps were to be avoided by a covering over the gage glass, the removal of the tool-boxes to a more accessible point and by the provision of water gages. A characteristic sight on American railways is men riding on the buffers of trains. This used to be done in England, but not to the same extent. As it jeopardized the men's lives the Board of Trade desired to compel the companies to always provide a caboose for the men to ride in. And the last point was the protection of section-men working on the track. These were to have flagmen stationed as look-outs to warn them when trains were approaching. All these features were embodied in the act of 1900.

THE HONDO IRRIGATION PROJECT of the U. S. Reclamation Service, located in southeastern New Mexico, is now completed, with the exception of some minor work. The usual low water supply is being received by the settlers, but next spring a full supply will be available. Mr. B. M. Hall, Supervising Engineer for New Mexico, Texas and Oklahoma, reports that, although the land in this project is all under private ownership, most of the farmers are cutting their holdings down to 40 acres. In 1907 one-tenth of the cost of constructing this irrigation system, or $33,300, will be returned to the Reclamation fund, and thus become available for use on other projects.

DRAW-SPAN OF THE INTERSTATE BRIDGE AT DULUTH-SUPERIOR, WRECKED BY A STEAMSHIP; OPENING A NEW PASSAGE IN FOUR DAYS.

The 491-ft. draw-span of the Interstate Bridge, connecting the cities of Superior, Wis., and Duluth, Minn., was wrecked by a colliding freight steamer at about 1 a. m. of Saturday, Aug. 11, 1906. A brief note of the accident was given in our issue of Aug. 16. Since then we have secured a photograph of the wreckage, which is reproduced herewith (Fig. 2), together with a view of the bridge before the accident (Fig. 1). For these views we are indebted to Mr. J. H. Goos, Assistant Engineer of the Great Northern Ry. at Superior, Wis. As the photograph of the wrecked bridge clearly evidences, the channel was entirely blocked by the fall of the bridge. The colliding steamer, a 6,000-ton steel vessel, struck the bridge just outside the fender timbers of the center pier, on the southern (Superior) side of the center. As Fig. 2 shows, the east sidewalk and roadway, supported on cantilever extensions of the floor-beams outside of the trusses, were cut through and the bottom chord was crippled. In this panel the bottom chord is at all times in compression, but carries maximum stresses when the bridge is swinging, as it was at the time of the accident. The fall of the bridge was a natural consequence, although, strangely, the bridge did not twist in falling as might been expected.

The wrecked draw is part of a combined railway and highway bridge over the narrow passage between Superior and Rice Point, a spit extending south from the Duluth shore. The bridge comprises a central draw-span 491 ft. long (two 200-ft. clear openings) and two fixed through spans of 301 ft. 9 ins., one on either side of the draw-span. The bridge was built in 1896 and the following year. It is a two-truss structure, with two railway tracks between the trusses, and outside the trusses two roadways and two sidewalks. The floorbeams are cantilevered out on each side far enough to carry a roadway next the truss and a sidewalk outside of the roadway. A street-car track ran on each roadway. While originally built principally for railroad traffic, the bridge has never been used for this purpose, but preparations have recently been by the Great Northern Ry., which now owns the structure, to establish train service over it. The bridge had a 50-HP. electric motor for turning and a 40-HP. motor for end lifts and rail lifts, and everything was planned for rapid operation. Mr. A. P. Boller, of Boller & Hodge, Consulting Engineers, 1 Nassau St., New York, N. Y., designed the bridge.

The importance of the channel, and consequently the disastrous effect of a complete closure, may be understood by remembering that this harbor is a heavy iron-ore shipping point. Duluth and Superior, at the western point of Lake Superior, lie on the north and south sides, respectively, of an estuary called St. Louis Bay, about 1½ miles wide, the mouth of St. Louis River. The line of the lake shore is continued across the estuary by a spit called Rice Point, closing off St. Louis Bay, the so-called inner harbor. About a mile east of Rice P[illegible]t and roughly parallel with it, is a great [illegible]escent-shaped bar, Minnesota Point, nearly [illegible] miles long, which closes off the outer harbor [illegible]perior Bay). Two passages give access to [illegible]perior Bay from the lake, one near the south [illegible] facing the city of Superior, and the othe[illegible] the north or Duluth end; the latter, an arti[illegible]al cut made in 1871, gave occasion for an i[illegible]ortant competition for designs for a movable [illegible]ge in 1892, and is now crossed by a ferry-bri[illegible] built in 1904. The inner harbor, however, [illegible] only one entrance passage. Now, the inner [illegible]arbor furnishes a much larger tonnage than t[illegible]outer, as most of the iron ore shipment com[illegible] from the inner harbor. The total freight m[illegible]ement is extremely high. Major C. L. Potter, in [illegible]harge of harbor improvements on Lake Superi[illegible] says in his 1905 report on Marine Commerce [illegible] Duluth and Superior:

> Considering the mean monthly freight movement during the season of navigation, Duluth-Superior Harbor practically stands next to New York,

which sufficiently indicates the importan[illegible] of the channels of access to the harbor, and particularly of the Gate, the passage through Rice Point.

At the time the accident occurred a large fleet of vessels was loading in the inner harbor. It was imperative, therefore, to open a passage through the bridge as rapidly as possible. While the street-car and wagon traffic across the bridge was important, it was far less so than the vessel movement through the Gate, and, moreover, there was no possibility of getting the wrecked draw out of the channels, not to speak of replacing it, for a period measured in weeks, if not months. It happens that there has always been a good depth of water under the fixed spans adjoining the draw, particularly the southerly one, for which the last report of the U. S. Lake Survey office quotes a depth of 20 ft. on the full width of the span. The fixed spans have a clearance of 18.7 ft. above the water, and it was therefore necessary to remove one of them in order to make a passage through the crossing.

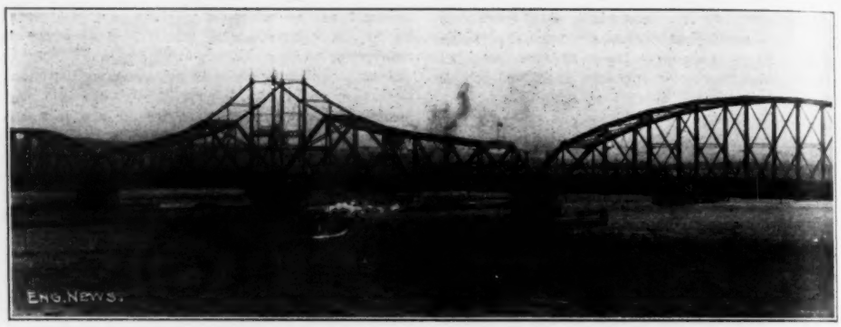


FIG. 1. DRAW-SPAN OF INTERSTATE BRIDGE BETWEEN SUPERIOR, WIS., AND DULUTH, MINN.

This task was undertaken at once, on the day of the wreck, by Whitney Bros., Contractors, of Duluth, for the Great Northern Ry. By clearing away some of the wreckage at the ends of the fallen draw, passage was provided for small craft such as local pleasure steamers. All boats of any size were compelled to await the removal of the Superior span. Four flat scows were lashed and braced together, and on them was erected timber cribbing to the level of the lower chord of the span. Four such supporting towers were built for each truss, to come under the first and second main vertical (that is, not counting the hip vertical; the span has ten panels). Meanwhile temporary timber supports on which to place the bridge for storage had been built along the shore, a short distance from the site. The pontoons were then pumped out, raising the cribbing against the span, and pumping continued to lift the span of its bed-plates until it cleared by several feet. The pumping was begun on the morning of Tuesday, Aug. 14, and at

FIG. 2. WRECKAGE OF DRAW-SPAN, INTERSTATE BRIDGE, DULUTH-SUPERIOR, SEEN FROM SOUTHEAST.
The 6,000-ton Steamer "Troy" collided with the draw on Saturday, Aug 11, 1906.

5.40 p. m. of the same day the structure started moving up-stream in tow of several tugboats. A number of vessels tied up in St. Louis Bay started out of the harbor immediately after the span was clear of the passage, less than four days after the wrecking of the draw.

THE ELECTRIC CRANE IN THE FOUNDRY.*

By Harry Sawyer.†

The first three-motor electric traveling crane built in the United States, and probably in the world, was for use in a foundry. It was put in operation only a little over 17 years ago. Although it was constructed from the wreck of an old rope-driven crane, it did good service night and day for nearly ten years. It was the invention of Alton J. Shaw, then employed by the E. P. Allis Co. as a designer, and was used in the foundry of its Reliance works at Milwaukee.

The use of the electric motor and the sliding contacts solved in so satisfactory a way the problem of transmitting power to a moving machine, that the traveling crane rapidly superseded the swinging crane in nearly all classes of foundry work where a crane is required. In one notable instance—pipe foundry work—the swinging crane was retained. Whether this was due to some peculiarity of the work that made the circular pit and the circular movement essentially better than the rectangular pit and corresponding crane movements, or whether it was due to the natural persistency of established practices, seemed for a time to be an open question; but the recent equipment of several pipe foundries with traveling cranes, indicates that the latter was the correct explanation.

It is no doubt true that the foundry has set the standard of excellence for electric cranes. Some shops and mills may have heavier loads to handle and require greater speed, but as a rule the requirements of the foundry are much more exacting. The conditions under which a foundry crane is operated are less favorable to continued good service than the conditions in a machine shop. It is more subject to overload, and the dirt and dust necessitate more careful attention.

There is at the present time something of a demand for excessively high speeds. The one advantage sought in high speeds is a saving of time, but this is often overestimated. Take for example a 10-ton crane with full load speed of 20 ft. per minute. We may assume that the average load will not be more than one or two tons, that the average speed for such load will be 30 ft. per minute, and that the average lift is 5 ft. Allowing 50% more time for acceleration from a state of rest, and we find the time for an average lift to be 15 seconds.

If the speed of hoist were doubled, it would at first appear that half of this time, or 7½ seconds, would be saved. If 20 lifts were made per hour, the result would be a saving of only about 4% of the time. When it is remembered that many of the lifts must be very slow, regardless of what the crane is capable of doing, and that traverse movements are usually started as soon as the load is clear of surrounding objects and before the hoist movement is stopped, the actual saving is reduced to a very inconsiderable amount of time.

Where a large floor area is covered, a greater saving can be made by increasing speeds of horizontal movements, but the swaying of load which results from high speeds and sudden starting and stopping, sets a limit to the saving that can be made in this direction.

Two objections may be offered to excessively high speeds: (1) The accidents that are likely to result from putting a high-speed crane in the hands of an incompetent operator often cause the loss of much more time than is saved by the higher speeds, and greatly increase the cost of repairs. (2) If the crane is not usually run at full speed, there is a constant loss of power in the rheostat, and unnecessary wear and tear on the controller parts, both of which cause expense and loss of time. The above comparisons apply with the most force to cranes in foundries, and with least force to cranes in mills, where much higher speeds are necessary and practical.

Next to the requirement of necessary strength in all parts for absolute safety, the most important point to be considered is perfect control of the hoisting mechanism. This depends upon three parts: the motor brake, the load brake, and the controller. The motor brake is released by the current which operates the motor, and should require only as much current as is necessary to drive the machinery without load. It should be sufficiently powerful to bring the armature to a stop promptly, but without shock, when the current is interrupted.

The load brake is a far more important part. It must allow the machinery to run freely in hoisting, but prevent the load from descending, except when the motor is run in the lowering direction. In most, if not all forms of load brakes now in use, the brake is applied by the action of the load. They may be divided into two classes; one in which the brake pressure is not reduced in lowering, but the motor acts with the load to cause the brake to slip; and the other in which torsion of the motor in the lowering direction reduces the pressure between the surfaces, allowing the brake to slip and the load to descend. The most common of the first class is the enlarged step bearing on a worm shaft. It can be used only in connection with worm gearing. It is a very simple and may be made a very satisfactory working brake. The most serious objection to it is that if proportioned to give a fair margin of safety with the best conditions of lubrication, it will take considerable power to lower with moderate or poor lubrication, for the motor must overcome any excess of holding power over that necessary to sustain the load. This extra work in lowering means loss of time and power, and greater wear of parts.

Of the second class, there are two types: the coil type and the disk type. Both have their advantages and disadvantages. The disk type is more substantial in construction, gives better distribution of pressure over the friction surfaces, and consequently a much lower unit pressure; and as the pressure is strictly in proportion to the load, it gives higher speeds in lowering light loads. It has this disadvantage, that it is more sensitive to irregularities in lubrication. In the coil brake the pressure and wear are concentrated principally at one end. While the brake is applied by the action of the load, the pressure and resistance to slipping are not strictly in proportion to the load. The torsional effort of the motor to release the brake is dependent upon the proportions of the brake parts, and not upon the load, hence the speed in lowering is approximately the same for all loads.

A good controller is indispensable to a satisfactory crane. The essential parts of the controller are the resistances and the means for varying the amount of resistance in the circuit, according to the speed and power required. The most common practice is to divide the resistance into sections, connect the sections together in series and connect each section to one of a series of corresponding contacts. A brush is arranged to pass over those contacts, cutting more or less of the resistance into or out of the circuit. Various materials may be employed and details used to obtain the desired result, but certain conditions must be complied with if satisfactory results are to be secured.

The total resistance may be sufficient to allow the passage of only enough current to start the motor at a very slow speed with its smallest load. The number of sections must be sufficiently great and the resistance of these sections sufficiently small that no sudden or abrupt changes of speed will occur from the time the first contact is closed, sending the current through the resistance, to the time that all the resistance is cut out and the motor is given full current.

Durability of the controller and convenience in making repairs are important considerations. The construction should be such that neither the resistance material nor the supporting insulation will be injured by the heat. Conservative rating and good ventilation are required to keep the temperature down to a safe point. Sparking and burning of contacts cannot be entirely prevented, but proper proportion of resistance to avoid great changes in voltage between consecutive steps, and a well designed magnetic blowout will prevent serious burning. The brushes and contact pieces must be renewed occasionally, and they should be very accessible. It is important also that the resistance material should be removable without moving the controllers from their positions in the operator's cage. Economy of space, so far as it is consistent with proper sizes of parts, good ventilation, good insulation and accessibility is of importance.

Crane motors are usually series wound. It seems almost unnecessary to say that they should be very simple and strong mechanically, that the electrical insulation should be of the best quality and that they should be designed to stand great variations in speed and load, and sudden reversals under load without injurious effects. The highest possible efficiency at some one speed and load is not so important as a good average efficiency over a wide range. Motors of low or moderate speeds are preferable on account of the reduced gear ratio required between motor and winding drum or driving wheel.

* Abstract of a paper read at the annual meeting of the American Foundrymen's Association.
† Muskegon, Mich.

METHODS OF MINING, HAULING AND SCREENING AT THE MINES OF THE ALDRICH MINING CO., BRILLIANT, ALA.*

By T. H. Aldrich, Jr.†

The Aldrich Mining Co. holds under lease from the Illinois Central R. R. Co. about 14,000 acres, in Marion Co., Ala., and owns other lands, of which about 1,000 acres adjoin this leased tract, making a total area of about 15,000 acres, all of which is underlaid by the coal-seam upon which the company is operating. This seam is nearly horizontal; and a ravine, diagonally crossing the tract, exposes the outcrop on either side for about two miles. The territory has been so divided that nearly the whole of it can be worked out by two collieries.

The mines at Brilliant were opened in the fall of 1898, and shipments began in the following spring. The original plan was to furnish steam-coal for locomotives to the Illinois Central R. R. Co.; and upon this expectation the investment of capital was made. The field was entirely new; and the softness of the coal at the outcrop induced the belief that it could be very cheaply mined. A contract for the delivery of a large quantity of coal to the railroad was accordingly executed. But with the advance of the entries to increasing distances from the outcrop, the coal proved so hard that it could no longer be drilled with a breast-auger; and the expense of mining became so great that the contract for cheap steam-coal had to be cancelled. It became evident that the work must be done with machinery and explosives, if it could be profitably done at all.

On the other hand, the excellent quality of this coal opened, at the same time, a possible market not specially contemplated at the outset—namely, that of a first-rate coal for domestic and general uses. Since no other deposit of such coal was known to exist on the line of the Illinois Central, or of any other railroad available as customer or carrier, and since the tract controlled by the Aldrich Mining Co. could furnish for a hundred years a large annual tonnage, it was obviously worth while to make extensive experiments, in order to perfect a system of mining, haulage, dumping, etc., which would effect the minimum cost of production—including under "cost" the items (known to all mining-managers as vitally important) of maintenance, repairs, interruptions, superintendence, etc., as well as those of construction, installation, and normally requisite labor. Moreover, it was necessary to a successful system that it should yield a product suited to the special market accessible to us.

It is the purpose of this paper to state with sufficient fullness the conditions of this problem, and the solution reached under those conditions, without going into such minute details as might both transcend the limits of available space and obscure the main outline of the principles followed. It is not assumed that the practice here described would be the best for other localities and circumstances.

The situation which we had to confront comprised three principal questions, involving the best method, respectively, of mining, hauling and dumping. These will be considered in order.

*Reprinted from the Bulletin of the American Institute of Mining Engineers, July, 1903. A paper read at the London Meeting.

†Birmingham, Ala.

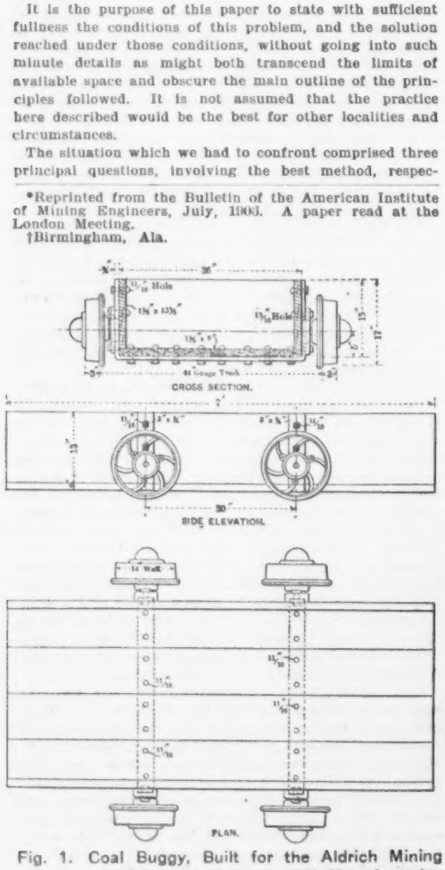


Fig. 1. Coal Buggy, Built for the Aldrich Mining Co. by the Decatur Car-Wheel & Manufacturing Co.

MINING.

The coal-seam was only 30 ins. thick, and almost horizontal in position. It presented no "butts" or "faces," and the coal was so tight between the top and bottom that it could not be shot "from the solid." I have seen chunks, 6 ft. wide and 4 ft. deep, thrown, by the firing of holes containing 40 ins. of powder, to such a distance from the face that a man could crawl entirely around them; and yet the coal remained as tight between top and bottom as before. There were no partings or soft streaks whatever. The roof was sometimes sandstone and sometimes slate, usually stratified sandstone. The bottom was fire-clay for about 4 ins.; then gritty clay for 10 ins.; then sandstone. The clay was too hard to be satisfactorily worked with any kind of machine; and sometimes the sandstone came up to the coal, with no clay between. Although the roof was excellent, and the mines were comparatively dry, mining was very difficult. The following methods were tried:

1. The long-wall system, using hand-labor with picks. This worked well; but the necessary number of skilled miners could not be obtained.
2. The long-wall machine, which likewise gave good results, but was open to the same objection.
3. Shooting the fire-clay from the solid, and then breaking down the coal with the pick.
4. A modified long-wall system, using narrow rooms, driven by hand, and then slabbed with a long-wall machine, which was run up one side and down the other, the face being followed with a slip track.
5. Cutting the bottom with compressed-air "punchers."
6. Under-cutting the coal in the same way.

Experiments 3, 4 and 5 were semi-successful; but the only really successful one was No. 6, in which the puncher cut the coal. When the bottom only was thus cut (No. 5) there was a tendency on the part of the machine-men to keep coming up into the coal; or, perhaps, the following machine-man would cut deeper than his predecessor, thus leaving the bottom in bad condition for laying the track. Moreover, it was difficult to get the men to cut the bottom at a reasonable rate of pay; and sometimes the operation was impracticable, because the cuttings of fire-clay formed a sort of mush which could not be handled.

COMMERCIAL CONSIDERATIONS.—Besides the direct cost of mining a given weight of coal, special commercial considerations were involved in our problem. The hardness of our seam prevented us from competing with innumerable other producers of steam-coal, but made us the only producers of high-grade domestic coal within a large region, especially in Alabama. Our lump-coal "stocks" well, not being liable to spontaneous combustion, or to serious decrepitation. After lying for eight months in piles on the ground it loses, in passing over the same screen, only 2%. This enables us to accumulate at the mines so much of our summer output as our customers will not buy and stock for themselves. (The market-price is higher in winter, when everybody wants coal; and Alabama consumers have learned to save money by purchasing at summer rates. But the contrary custom has long obtained in Mississippi; and such habits are hard to change.) While we would be glad to make immediate summer deliveries at summer rates, we must stock our own coal somewhere, if our customers prefer not to do so; for, as all colliery managers know, fluctuations in the labor force and in output, due to fluctuations in market demand, are economic evils of the worst class, injuring employers, employees and consumers alike. We have found that by stocking coal at the mines, instead of the yards where it is sold, we can save as much as 40 cts. per ton—partly in interest on the high freight rates to local railroad stations, which we thus avoid paying until the coal is actually called for.

Since lump coal is our chief profitable product, and is, moreover, the size which can be stocked, as above described, with minimum loss, it is obvious that we must produce as large a proportion of lump coal as possible, and that the size so denominated shall be as small as can be sold to consumers, or stocked without deterioration. This size has been fixed by experience to be that obtained by the use in the screen of round 2-in. holes, as further described below. The maximum production of such lump coal requires the reduction of the machine-cutting of coal to a minimum. As already explained, we found it better to do the under-cutting in the coal than in the floor. This being the case, it was important to know which machine would give us, as a net result, the largest proportion of "lump," and the most favorable proportions of "nut" and "slack." Our experience thus far has indicated the Harrison "P. G." type as the best for our special case, on account of its ability to make a very low cut. The use of this machine gives us, of the total coal broken, about 65% lump (worth, say, $2.10 per ton), and 35% nut and slack (worth, say, $1.10 per ton). As compared with other machines which we have tried, and which yielded a smaller proportion of lump, this might save, upon the mining of 500 tons daily, for 275 days in the year, more than $30,000.

NATURE OF MOTIVE POWER.—The coal-cutting machines are run by compressed air, although electric power is used for haulage. Undoubtedly a large further saving could be effected by the use of electrically-transmitted power for coal-cutting, which would eliminate the serious cost of purchasing, laying, maintaining, repairing and renewing pipes, hose, hose-fittings and valves, besides reducing the items of fuel and power-house expense. In so small a seam, the amount of coal won for each

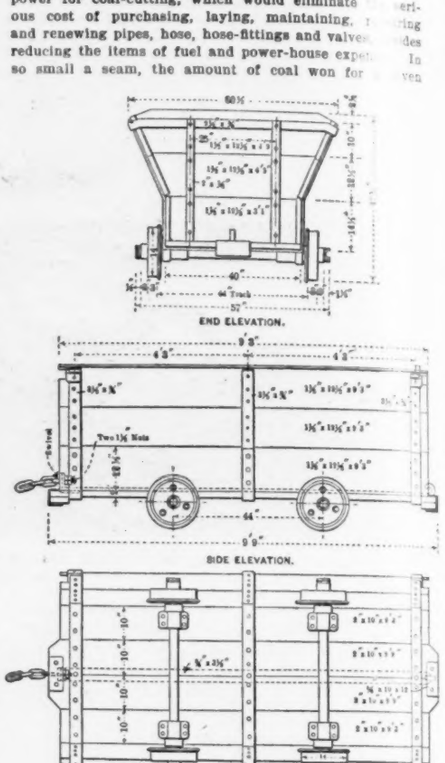


Fig. 2. Three-Ton Coal Car of the Aldrich Mining Co.

amount of cutting is relatively small; that of pipe-laying per ton is correspondingly large, the distance to be covered with pipes increasing very rapidly; and the pipe remaining permanently in the mine, practically never to be recovered, represents in all $10,000 per 75,000 tons of coal mined. Moreover we have found the efficiency of the power transmitted by compressed air to be small in our practice. The coal burned at the power-house for each of our collieries is approximately 175 tons per month for each 100 tons of coal mined per day. Again, the mine water rapidly corrodes our pipes and valves; all of the latter constantly leaking. Finally, the workmen habitually turn on the compressed air, in order to blow the smoke away, after blasting; and it is difficult to prevent this waste of power. These facts warrant the conclusion that, for our particular conditions, the electric transmission of power for the cutting of coal would effect a large saving in running expenses.

LABOR COSTS.—As already explained, mining is done by contract, each contractor receiving one machine and one entry, and delivering the coal on a large car for 75 cts. per ton (or on a small car, where the old system, involving switches, is still in use, at 65 cts. per ton). He pays his men according to a schedule fixed annually on July 1, by agreement between the company and the men, from which he is not permitted to depart. The labor union known as "The United Mine Workers of America," formerly organized in this locality, insisted upon the system followed in Indiana and Pennsylvania, according to which the company pays for the cutting, and the miners contract for the rest of the work—cleaning up, timbering, track laying, etc. This system would be advantageous for both the company and the miners, if the latter were loyal and industrious. Unfortunately, in our district, the men were like spoiled children, recklessly disregarding both their own interest and that of their employers, and working or not working, according to their whim. Under the system mentioned, we found that twice as many rooms and nearly twice as many men were required for a given output, and that this output was very irregular. On some days, all the rooms would be only partly cleaned, so that none were ready for the machine. On other days, all the rooms would be ready simultaneously, while, of course, the machine was not available for all at once. It was impossible to get the men to clean up the rooms so that they could be made ready for the machine in regular succession; and consequently they were continually wrangling for precedence

in this respect. Under these conditions, the output of coal per machine was on one day 30 tons; on the next, perhaps nothing; and the average was not much more than 15 tons. Under the contract system now in force, the average output is somewhat more than 30 tons per day. A man desiring to leave one contractor and to work for another must either have the consent of the former or give three days' notice.

The following is the present wage schedule:

Coal shooters, $2.50 per day; machine runners, $0.045 per ft. or $2.50 per day; machine scrapers, $0.03 per ft., or $1.[illegible] per day; daily wages of drivers (one mule), $1.40; (2-mule teams), $1.65; (3-mule teams), $1.75; trackmen, $2.25; miners, $2.25; outside labor, $1.25; blacksmiths, $2.35; helpers, $1.25 to $1.50; car trimmers, $1.25; couplers (boys), $0.90; (men), $1.35; motor runners, $1.50; dinkey engineer, $45 per month; weighman, $40 per month.

HAULING.

We tried several systems of hauling, employing at first 1-ton cars, 30 ins. high, which were loaded in the rooms. This required that 10 ins. of bottom be taken up in the

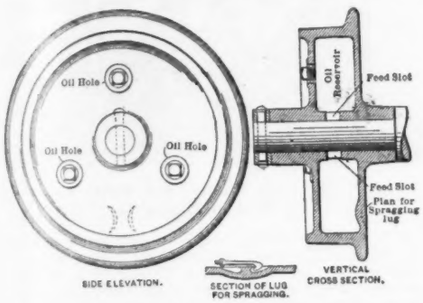


Fig. 3. Solid Cast-Iron Wheel for Three-Ton Mine Cars.

rooms, and switches be placed at the room-necks. Later, we gained the necessary head-room from the top, instead of the bottom, because the latter, when blasted, came up badly, leaving "potholes," and not lifting in slabs or flakes. Still later, the cars were remodeled, so as to be exceptionally wide and only 18 ins. high from the top of the track rail. This made the place of loading so low that it was impossible to use any end gate. We experimented with perhaps 100 kinds of gates, using in turn a sloping iron plate, a bar across the front, a chain across the front, half an end, and all manner of other devices to keep the coal from coming out. All failed, because the lumps were so large, and the space was so small in which to load them. When the coal was shot down, the center yielded large, flat flakes, while the top and bottom of the seam broke with a cubical fracture, and gave a good deal of small coal, in addition to which the machine-cuttings had to be loaded and hauled out. The coal spilled badly in the gangways, causing many wrecks, much loss of coal, many crippled mules, and great expense for keeping the roads clean and the ditches open.

We tried next a large car, 6 ft. long, 6 ft. wide and 14 ins. high, running on a 3-ft. gage, with the wheels up in the car body, protected with a cast-iron housing. This was satisfactory in many respects; but, proving clumsy to handle and to put on the track, difficult to oil, and requiring, moreover, the keeping of the track very clean, it was finally abandoned.

We then tried to increase the capacity of the car by running the bottom plank under the axle, instead of over it, and increasing the length, height and width of the car to a maximum. This experiment was also a failure, because the least little lump on the roadway would cause a wreck. Besides, for a product of 400 tons a day, it involved the daily handling of 800 small mine cars, holding only 1,000 lbs. of coal each, and thus required so many cars and mules, besides involving so much difficulty on the tipple, that a larger car was indicated as an absolute necessity. Moreover, by reason of the thinness of the seam, the rooms were worked out so fast that this system had not a sufficient radius of action without serious increase of cost.

Then we tried the old Welsh buggies, delivering the coal to cars; and finally, we adopted a type of buggy made with two rib irons, four trunnion wheels on the sides of the irons, and five pieces of plank, with no draw-bars, bumpers or end-gates. (Later, end-gates were adopted, consisting of a plank lifting out between two guides, similar to the tail-gate of a wagon.) These buggies, which were used in the rooms only, had 14-in. wheels, were very light and cheap, could be pushed easily, and were hung so low that the bottom was on a level with the top of the rail, and the miner could load the largest lumps over the sides or ends, without laboriously building up the load. Fig. 1 shows the construction of such a buggy.

This is the system now employed. At the mouth of the room-neck, one "brushing-shot," tearing down 3 ft., is made, and, when the buggies have been pushed to this point, the coal is transferred with a shovel from the buggies to large cars in the entry, holding 3 tons each, and having solid ends. The construction of these cars is shown in Fig. 2.

The main entry is laid with 25-lb. rails, with splice-bars and bonds; there are no room-neck switches; no coal is spilled in the roadway; no cleaning of track is necessary; and the hauling is done entirely by electric power, mules being dispensed with altogether.

As already explained, mining is done by contract. Each contractor takes charge of one machine and one entry, and, as a rule, turns out 30 tons a day, the company taking the coal from him at 75 cts. per ton on the 3-ton cars. Such a contract, delivering 30 tons a day, requires ten large cars, five of which are pushed into place in the morning and removed at noon, when the other five are put in their place. The motor makes two trips a day to each entry. On each trip, the front car is a rock car, having side dumps, and holding six tons of rock, which is about half of one "brushing-shot." With the two rock-cars furnished, the contractor can, therefore, clean up a brushing-shot each day. Since these cars are of the same size as the coal cars, he can load them with coal if desirable.

The advantages of this system of buggies, combined with large cars and electric haulage, are as follows:

(1) The absence of switches makes pipe-laying easy. Sometimes an entry will go 0.25 mile without encountering water, and suddenly there will be so much water in one place that a suction-pipe or a pump must be installed. Under the old system, this pipe might have to go under a dozen switches, at great trouble and expense.

(2) No top is taken down and no bottom is taken up in the rooms, since the buggy follows the seam. Under the old system, the "yardage" paid for this work of "room-brushing" amounted to 6.1 cts. over and above the mining pay of 65 cts. per ton, making the total labor cost 71.1 cts. per ton, of which the loaders got 20 cts. Under the present system, 5 cts. more is allowed to loaders, and 5 cts. to the contractor, making the cost of the coal on the big car 75 cts., as against 71.1 cts. per ton. Experience has shown that, besides receiving more per ton, the loaders load more tons per day. They never have to wait for cars. The large cars spill no coal on roadways. The cost of the maintenance of cars is smaller, as is also the number of cars required.

(3) The smooth main track permits of high speed, thus giving the motor greater range of action, and securing a greater utilization of gangways and tracks, in proportion to the repairs inevitably required by lapse of time.

(4) Drivers and mules are eliminated.

(5) Many fixed charges and contingent expenses, such as mule feed in time of strike or shut-down, are greatly reduced.

(6) Per ton of capacity, the investment in cars is much smaller. One of the old cars weighed 1,000 lbs., held 1,000 lbs. of coal and cost $33 made up. One of the cars now used weighs 2,000 lbs., holds 6,000 lbs. of coal, and costs $47. In other words, the dead weight, formerly equal to the weight of coal, is now only one-third thereof.

(7) By reason of the superior design of the present cars, the cost of maintenance per car is no greater than before; and, since the number of large cars per ton of coal mined is much smaller, the actual expense of this item per ton is only one-fifteenth of what it used to be.

(8) This system requires no additional excavation. For both sizes of cars, the entry must have practically the same dimensions, namely, a height of 5 ft. 4 ins. above the rail and a width of 8 ft. The satisfactory operation of any such system depends, of course, upon the perfection of its details. Some of these will, therefore, be more particularly described.

CAR WHEELS.—The wheels of mine cars are subjected to exceptionally severe wear and rough usage. The cars, having neither buffers nor brakes, are jammed together or jerked apart in hauling, or violently checked by "spragging;" the tracks are not kept in perfect condition or repaired oftener than is absolutely necessary, and the wheels are consequently jolted over irregularities and bad joints, or thrown off the rails by unnoticed obstacles, and rudely jerked on again; frequently they are covered with water; the gangways are dark, and close supervision of the haulage is impracticable; it is not always easy to detect the necessity, or perform the process, of lubrication; and, finally, the employment of as little and as cheap labor as possible is required in the operation of trains. On the other hand, the direct expense of repairs to the cars, and the inconvenience and interruption thereby occasioned (which may amount to a still greater loss) render it vitally important that the car wheels shall run as long, and require as little personal attention as possible. The strength of the whole chain of the haulage system is, according to the proverb, no greater than the strength of its weakest link; and hence improvements in the design of a car wheel may be as important as much more ambitious inventions. The wheel here described therefore constitutes an essential element in the success of the general system adopted by our company.

Fig. 3 shows the construction of this wheel, which is a solid casting, having no parts (except the oil plugs) which can be loosened or detached. The leading purposes of the design are to secure maximum strength for the weight of metal; uniform wear of parts; and facility and certainty of lubrication:

(1) By plates, bracing the sides of the rim, a proportional strength, greater than that of wheels with spokes, is secured. Spragging may be provided for by means of a wedge-shaped lug in either web, with a hook, adapted to catch and hold the wheel.

(2) Uniform wear, essential to durability, is secured by an equal distribution of strain upon the bearing, and of lubricant upon the surface exposed to friction. The equal strain is obtained by means of a hub presenting an integral bearing-surface, bisected by a vertical longitudinal plane through the center of the tread of the wheel. The pressure per sq. in. is, therefore, the same at all points of the bearing surface; and the wheel moves in true alinement with the direction of motion of the car, until it is completely worn out. The importance of this feature cannot be too much emphasized. An unequal distribution of the thrust on the bearing causes a greater wear on one side of the center, tending to a deformation which, however minute at first, is rapidly multiplied, throwing the wheel more and more out of alinement, so that its flange not only cramps and wears the rail, but also becomes increasingly liable to "trip" at switch connections, and to wreck the car.

(3) For the purpose of lubrication, the wheel is cast with webs, enclosing a large oil-chamber, which extends from hub to rim, and is so large that three or, at most, four oilings per year will be sufficient. When so great a quantity of lubricant is provided, a method of feeding is obviously required which, while not liable to clog, will supply no more oil than is necessary, and will evenly distribute this supply. This is effected by one or more entirely open and unobstructed longitudinal openings or slots in the hub, leading directly from the reservoir to the axle, and so proportioned as to catch, as the wheel revolves, a suitable amount of the film of oil on the sides of the reservoir, and feed it to the center of the bearing surface. When packing or waste is placed over or in the oil-ducts, they are liable to become clogged; and this liability calls for that closer attention to the wheel which it is desirable to render unnecessary.

In the present usual practice, the outer ends of the hubs are packed, to hold the oil in, and to protect the bearing against the entrance of grit and dirt. This involves an uneven lubrication, and also prevents early indication of the fact that the wheel has become dry. In the wheel here described, both ends of the bearing are left open, so that the oil, introduced at the center, and flowing evenly outwards in both directions, tends to prevent dirt from working in, and also shows at all times the condition of lubrication. The waste of oil, which should be prevented by a proper adjustment of the feeding orifices, is easily noted at once; and, when the lubricant has been exhausted, the whole bearing becomes dry at the same time, the fact being patent upon the most superficial outside inspection.

Without dwelling upon other details of this design, I may mention as worthy of notice two subordinate features, which are more important in practice than they look on paper. The first is, that the openings through which the oil reservoir is charged are so disposed that, if (as happens much oftener than it ought to happen) a plug is carelessly not replaced after filling, there will be no serious loss of oil. The second is, that these plugs are made large enough to prevent their being so battered or twisted off by accidental underground shocks, such as careless wrenching, as not to be easily extracted. Any engineer who has experienced the exasperating necessity of actually drilling out a jammed plug of this kind will appreciate the value of this feature.

The wheel here described has demonstrated, by long continuous use, the superior durability, evenness of wear, and freedom from the necessity of attention above claimed.

CAR COUPLINGS.—The couplings of the large cars employed in this system of haulage are so designed as

Fig. 4. Rock Car, with Shutters for Side-Dumping.

to permit at the tipple the tilting of each car, without breaking its connection with the preceding or the following car, and thus the connection of the train with the motor which pulls it. This problem is not difficult. It was solved in our practice by using, for the large cars, couplings consisting of three links and an eye-bolt, which is held on with jam-nuts, and the shank of which passes through the up-turned end of the draw-bar. The other end of the draw-bar is a hook; and the eye-bolt acts as a swivel.

(See Figs. 2 and 4, the latter of which shows a rock-car, like the mine-car, except that it has shutters for side-dumping. The coupling is the same for both, since the rock-car, if it should happen to be loaded with coal, would have to be dumped by tilting.)

Fig. 5. Scale and Tipple Dumping the Last Car of the Train.

Fig. 6. Tipple, with Single Track Trestle, Serving Mines on Both Sides of the Ravine.

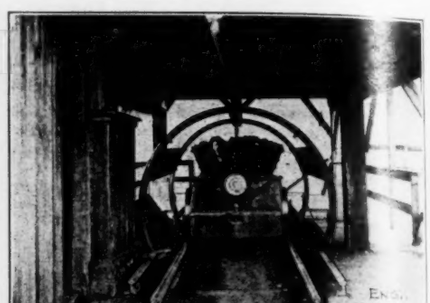


Fig. 7. Overhead Trolley, and Motor Passing Through Tipple.

DUMPING.

The tipple (Figs. 5, 6 and 7) is a cylindrical frame, rotating on trunnion wheels, and so arranged as to permit the weighing and dumping of each car of a mine train, without breaking the train or disconnecting the motor, and in such a manner that one man only is employed on the tipple, attending to both weighing and dumping. Incidentally, it was necessary to provide a device which would automatically arrest and hold upon the tipple, for the purpose of dumping, each successive car of a train, while permitting the motor which hauled the train to pass over the tipple, without being thus held and overturned. This was accomplished by causing the retaining device to engage the wheel hubs, instead of the wheel rims, of the cars, so that the hubs of the larger wheels of the motor would pass above it, and escape its action altogether, without the need of any moving parts, or human intervention, to prevent the motor from being caught and dumped.

This system of continuous weighing and dumping (equally practicable with a steam locomotive) is operated at the mines of the Aldrich Co. with an electric locomotive as follows:

The train of loaded cars is hauled to the dump, and stops for a moment, with the motor on the tipple (the trolley wire running through it), and the first car on the weighing scale. When this car has been weighed, the motor goes forward, bringing that car upon the tipple, where it is caught and held, while the second car, simultaneously brought upon the scale, is weighed. During the weighing of the second car, the tipple is revolved, and the first car is dumped and returned to position, without severing its connection with either the motor or the following car. The motor then advances again, and the second car is brought upon the tipple and dumped, while the third is weighed—and so on through the whole train. The interruption of train movement required for weighing (and the simultaneous dumping of a preceding car) is very small. In fact, a skillful weighman, operating the tipple by means of a small lever, can weigh and dump all the cars of a train in slow motion, without really stopping them at all. After the rotation of the tipple has been thus started, the remainder of its movement is automatic; it revolves completely, comes back, and cushions itself properly in its former position, without further attention.

A small tipple of this kind, operated with the small 1,000-lb. cars, dumps regularly seven cars, and, on a test-run, has dumped eleven cars per minute. The large tipple has a regular rate of four 3-ton cars, and has dumped, on a test run, seven such cars per minute. In fact, the capacity of the tipple is practically limited only by the capacity of the shaking-screen placed below it to receive the coal.

The tipple is simple and (consisting, as it does, of riveted work) very solid. The motor car can run through the tipple as fast as 20 miles per hour without injury to anything. It needs no attendance; does not get out of order; requires a single track only, thereby saving the cost of wooden trestles, etc., and is, on the whole, cheaper in construction and operation than any other automatic tipple.

The details of construction, coupling, arresting and holding of cars, and tilting mechanism for the tipple are simple, though, of course, important with reference to the supreme need, in such an operation, of solidity, stability, safety and certainty of automatic operation. Mine-managers cannot afford to use machinery of this kind, however ingenious, which is liable to break down.

SCREENING AND WASHING.

As already remarked, the most advantageous limit for lump coal has been found to be that of a 2-in. round hole in the screen. The screens upon which the coal is dumped have, therefore, holes of this size. The lump coal thus produced sells at an average price of $2.10 per ton.

Two systems of disposing of the smaller coal passing these screens are now in use:

(1) Under the first system, used at mine No. 1, this coal is run over a screen having 0.75-in. round holes; the over-size is sold as "nut" at the average price of $1.35 per ton; and the under-size, after washing in a simple trough-washer, is sold at 50 cts. per ton. (This washer is very wasteful. It is estimated that 600 tons of coal per month go down stream from it. But this estimate is probably too high.)

(2) Under the second system, used at mine No. 2, all the small coal (under 2-in. diameter) is elevated and washed in jigs. The jigging is extremely simple, because there is no dirt sticking to the coal. The seam has no partings, and is absolutely clean coal from top to bottom, so that, apart from the usual slate broken from the top, the only foreign matter is fine, hard fire-clay, separated from the floor by the picks of the under-cutting machine. This fire-clay, however small in amount, is extremely objectionable, and, unless removed by washing, ruins the coal. The total weight of all impurities thus removed is about equal to the weight of the moisture in the cleaned product, so that the jigs practically furnish, by weight, as much salable coal as they receive of crude material. This product is sold without further sizing at $1.10 per ton.

The two systems may be compared as follows: For every 100 tons of coal mined, mine No. 1 produces 53 tons of lump, 27 tons of nut and 10 tons of slack; and 10 tons is washed away by the trough-washer. At the values given above, this would net $152.80, or $1.528 per ton. In mine No. 2, 65 tons of lump would be produced, and 35 tons of washed, nut and slack, netting the company $175, or $1.75 per ton.

Against the second system must be charged a slight increase in the cost of washing, due to the difference between operation, maintenance, etc., of the jig and trough-washer plants. This is a very small item and, from the data available, cannot be figured, one man being required to operate the washer in either case, the sole difference being in power and maintenance, the item of water-supply being decidedly in favor of the jig system. After making such allowances, the No. 2 system is markedly preferable, because of the utilization of fuel, which would otherwise be lost forever. We have found the horizontal shaking-screen the most suitable for our purpose.

SUMMARY.

In the foregoing outline, the nature and extent of the economies effected as the result of our experiments have been briefly stated. The total improvement has been estimated in an official report, based upon actual practice, and dated about a year ago—since which time changes in the market prices of coals, the labor situation and the conditions of railway transportation have largely increased the advantages of the new system.

The report referred to is a comparison between the old system of small cars, room-switches, mule-haulage, sizing, washing, etc., employed in colliery No. 1, and the improved system of buggies, large cars, and electric haulage, sizing, jigging, etc., as perfected and practiced in No. 2. It shows that, under the new system, the whole plant is more cheaply constructed and maintained; that there is a greatly increased storage capacity in mine cars (an important item, in view of the present scanty and irregular supply of railroad cars in this region, as everywhere else in the United States); that contractors and their workmen earn more money, while daily output of coal per man is increased; that for [illegible] of 250 tons per day the number of workmen, [illegible] those employed by the contractors, is reduced [illegible] 16, a saving of $41.35 per day; that there is an [illegible] saving of $27.85 per day in mule feed, [illegible] laying of pipes and tracks, etc.; that the [illegible] saving in these items of current running expense [illegible] to 27.68 cts. per ton of coal mined, while the [illegible] in the receipts from sales averages 22.20 cts. [illegible] making a total of 49.88 cts. per ton as the net [illegible] of the improved system as a whole.

It is scarcely necessary to say that this result, effected in the production of a material, the selling price of which per ton ranges from $2.10 down to $0.50, and has averaged under the old system about $1.50, and, under the new, about $1.75, is important enough to make all the difference between business success and failure, and therefore justifies the costly experiments and the radical innovations involved in the adoption of the improved system above described.

RAISING GAS MAINS AT GALVESTON, TEX.

Raising the surface of the city of Galveston, Tex., to the grade made possible by the new sea wall has given rise to many interesting problems. Among these are the raising of gas mains. A paper on this subject was presented at the recent Cleveland convention of the Western Gas Association, by Mr. John Gimper, Superintendent of the Galveston Gas Co.

As explaining the problem with which he had been confronted, Mr. Gimper stated that 11,000,000 cu. yds. of filling required for the new level is being effected by pumping in sand and water and letting the water drain off through suitably prepared channels. Contractors are allowed to fill 16 blocks at a time. The territory being filled consists chiefly of the residence part of the city. The sea wall already mentioned is three miles long and 16 ft. high above sea level. Its construction is one of the consequences of the storm of September, 1900, which wrecked a large part of the city. The gas mains affected are 3 to 8 ins. in diameter, and the fill in these sections is from 3 to 8 ft. in depth. Owing to previous grade raisings, however, the old mains, before their recent raising, were from 4 to 5½ ft. deep.

The three possible methods of raising the gas mains are stated by Mr. Gimper as follows:

(1) To raise the mains after the grade had been completed, laying new ones where the old ones could not be profitably raised. This plan was adopted by the City Water Department.
(2) To take up the mains in the sections to be filled and relay them to conform to new grade when completed.
(3) To raise the mains before the grade was raised.

The experience of the city water department showed that the first method was impracticable. The second method was also considered impracticable by the gas company, since it would result in considerable loss of business. The third method was therefore adopted, without interruption in the supply of gas. The method employed is briefly described by Mr. Gimper as follows:

The raising of the mains was accomplished with chain blocks and derricks after stripping mains and services. No special engineering features were called for; care had to be exercised not to place derricks too far apart; raising was done simultaneously with all the blocks, and all services had previously been cut. Filling followed at once under the main, and when raised high enough two solid beds were tamped under each length of pipe, and a

piece of 2 × 8 × 18 or 20 ins. long of yellow pine was tamped to true grade; all the joints were then cleaned and calked over.

It may be added that the old joints were made with lead, and that, it being necessary to raise houses as well as the ground level, a piece of garden hose was used to connect the service with the vertical riser until permanent connection was available.

FURTHER TESTS OF THE EFFECT OF OIL ON THE STRENGTH OF PORTLAND CEMENT BRIQUETTES.*

Recent investigations as to the effect of various oils on Portland cement, described in Engineering News of Mar. 16, 1905, suggested the possible serious disintegration of concrete when exposed to the action of oil. Some further tests are here presented which show the comparative strength of Portland cement briquettes, both neat and of a 3 to 1 mixture, when immersed in water and in oil.

The first experiment (Table I) shows the comparative strength of briquettes immersed in water for two years, and briquettes immersed in water for two years and in oil for six months additional. (In the latter case there was an interval of seven days drying in air.) It will be readily seen from the table that the neat cement, Alsen's alone excepted, deteriorated after treatment with oil, while the 3 to 1 cement improved in strength.

TABLE I.—COMPARATIVE STRENGTH OF PORTLAND CEMENT BRIQUETTES IMMERSED IN WATER FOR TWO YEARS AND OF BRIQUETTES IMMERSED IN WATER FOR TWO YEARS AND IN OIL FOR SIX MONTHS.

(These cement briquettes after being taken from the water, were allowed to dry in the air for seven days.)

Brand.	Immersed in.	Breaking strain in lbs. per sq. in. after being in water 2 years.		Breaking strain of briquettes after being further immersed in oil nearly 6 months.	
		Neat.	3 to 1	Neat.	3 to 1
Alsen's....	Neatsfoot oil	818	435	520	720*
"	Olive oil	818	435	605	700*
"	Lardine oil	785	468	625	505
"	Benzoline	785	468	520	580
"	Sperm oil	451	348	640	550* †
"	Kerosene	451	348	580	350* †
Colonial...	Neatsfoot oil	740	328	700	390†
" ...	Benzoline	740	328	600	400†
" ...	Kerosene	776	356	525	480
" ...	Sperm oil	776	356	560	505
" ...	Olive oil	718	318	680	470†
" ...	Lardine oil	718	318	600	420†

* Snapped like flint in the breaking machine.
† Not completely saturated.

In the second experiment (Table II) the briquettes, after drying for seven days in air, were immersed for about six months either in oil or in water. Those immersed in oil showed a considerable depreciation in strength as compared with those cured in water. Those made with the 3 to 1 mixture showed the greater depreciation in this case.

TABLE II.—COMPARATIVE STRENGTH OF PORTLAND CEMENT BRIQUETTES IMMERSED IN WATER FOR SIX MONTHS AND OF BRIQUETTES IMMERSED IN OIL FOR SIX MONTHS.

(These briquettes were exposed to the air for seven days after they were made and then were immersed in oil or in water, as noted.)

Brand.	Immersed in.	Breaking strain in lbs. per sq. in. after being in water 6 mos.		Breaking strain after being further immersed in oil nearly 6 mos.	
		Neat.	3 to 1.	Neat.	3 to 1.
Colonial...	Neatsfoot oil	666	234	380	75
" ...	Sperm oil	666	234	300	75
" ...	Kerosene	666	234	550	110
" ...	Olive oil	666	234	660	50
" ...	Lardine oil	666	234	430	55
" ...	Benzoline	666	234	480	120

In the third experiment (Table III) the briquettes were immersed in water the day after they were made, and some were left there for nine weeks. Others were taken out at the end of four weeks, allowed to dry in air for one week, and then immersed in water for four weeks more. The two kinds were, then, of the same age when tested. The results were as follows: In neatsfoot oil and in sperm oil, Colonial cement, 3 to 1, showed depreciation; Colonial neat cement in sperm oil showed an increase in strength. Lion neat cement in sperm oil, kerosene and benzine showed decrease; the 3 to 1 mixture an increase in all oils. Alsen's neat cement decreased in strength in all oils except olive oil, in which it shows a remarkably large increase; the 3 to 1 mixture shows increase in all oils.

By way of comment on these results it may be said that the deterioration of neat cement when subjected to oil, is not of serious import commercially, since the material is never used by itself in practice. In the case of the 3 to 1 mixture, on the other hand, the experiments show that if concrete is allowed to set in water for some time before the application of oil, no ill result need be feared. It would appear, therefore, that cement or concrete floors may safely be used in oil stores and similar places.

*Based on experiments made under the direction of A. B. Moncrieff, M. Inst. C. E., M. Am. Soc. C. E., Engineer-in-Chief South Australia, Adelaide, South Australia.

A STEAM MOTOR CAR for the Bavarian State Railways (Germany) has a very peculiar type of driving gear. The four-wheel driving truck has outside cylinders placed midway between the axles, and the piston rods extend through both cylinder heads, with a connecting rod to each wheel. The wheels are connected by coupling rods. In some small four-wheel tank locomotives for light railways, however, the same driving mechanism is employed, but without the use of the coupling rods. These motor cars and locomotives have recently been built by the Maffei Locomotive Works, of Munich, Germany.

THE DESIGN OF PLATE-GIRDER WEB SPLICES.

By R. T. Logeman.*

The following remarks pertain to the design of web-splices in plate-girder bridges, and are given with the thought of simplifying the design of a splice to resist both shear and bending moment. When the web-plate is considered as carrying only shear, the current methods of design are simple enough. More recent specifications, however, almost universally recognize the fact that the web-plate also carries its proportion of the bending-moment. This assumption, which seems unavoidable if the actual function of the web is considered, requires that the web-splices be designed strong enough to transmit this bending-moment.

In the following, the strength of the web-splice in the lower or tension half is alone considered, in accordance with usual practice, and the upper or compression side is made the same. In making the deduction for rivet holes, the diameter of the holes is assumed to be ⅛-in. larger than the diameter of the rivet before driving.

Assume a girder of any length or depth, and a web splice at any place in such a girder. Assume also that at the web splice in question, the amount of the shear or the amount of the bending moment that the web is carrying, is not known. If there is sufficient net section in the web plate at the end of the girder to take care of the end shear, there will always be enough net section in the web plate at the splice, provided, of course, the number of rivet holes are not materially increased, or the thickness of the web plate materially decreased, which is nearly always the case. In regard to the amount of bending moment carried by the web, it is clear that this cannot be greater than the net resisting moment of the web (i. e., with deduction for rivet holes) on the basis of a maximum stress in the extreme fibers equal to the flange stress. For, the extension or compression of the flanges fixes the extension or compression of the web fibers immediately at the flange, and correspondingly fixes the longitudinal stress in these fibers.

With these conditions in mind, the consideration of the web splice can be taken up, and it can be said in advance that if the web is properly spliced for the full value of its net section, this same splice can be used anywhere in the girder, and on the basis of net area, this spliced web will resist as much in bending, or in combined bending and shear, as a similar unspliced web. Depending upon the location of the splice in the girder, a slight modification must generally be made in the length of the horizontal splice plates that extend over the flanges, but this question will be considered in detail further along.

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TABLE III.—COMPARATIVE STRENGTH OF PORTLAND CEMENT BRIQUETTES IMMERSED IN WATER FOR NINE WEEKS AND OF BRIQUETTES IMMERSED IN WATER FOR FOUR WEEKS AND OIL FOR FOUR WEEKS.

(All these briquettes were immersed in water the day after they were made. Those for oil test were allowed to remain in water for four weeks, then allowed to dry in air for one week and then immersed in the various oils for four weeks. Those for comparative water test were immersed all the time in water. All the briquettes were the same age, i. e., 9 weeks, when broken.)

	COLONIAL CEMENT. Breaking strain in lbs. per sq. in.					LION BRAND CEMENT. Breaking strain in lbs. per sq. in.					ALSEN'S CEMENT. Breaking strain in lbs. per sq. in.				
Immersed in.	Neat.	Average.	3 to 1.	Average.	Remarks.	Neat.	Average.	3 to 1.	Average.	Remarks.	Neat.	Average.	3 to 1.	Average.	Remarks.
Water.....	495		230			600		335			870		370		
	375		155			455		335			930		340		
	680		145			665		315			880		410		
		516		175			573		328			893		373	
Lardine oil...	485		215		Saturates	625		455		Snapped like	680*		520		*Bad
	720		200		1/16 in.	620		445		flint. Saturates	940		620		briquette.
	640		165			540		420		slightly—not	910		620		Saturates
		615		193			595		440	more than 1/16 in.		843		586	1/16 in.
Olive oil.....	860		230		Does not	650		465		Snapped like	1250		605		Snapped like
	280		170		penetrate.	540		600		flint. Does not	975		515		flint. Oil does
	610		185			710		545		penetrate.	935		615		not penetrate.
		650		195			633		536			1053		578	
Neatsfoot oil.	650		155		Penetrates	720		480		Oil penetrates.	820		550		Oil penetrates
	585		199		more than	485		480		*Bad	910		500		more than other
	610		160		other oils.	*		470		briquette.	730		530		oils.
		615		171			602		476			820		526	
Sperm oil....	860		145		Saturates 3 to 1	485		420		Penetrates 3 to	620		475		Penetrates 3 to
	455		145		but not neat.	630		370		1—¼ in. and	600		550		1—¼ in. and
	855		150			520		380		neat ¼ in.	535		560		neat not more
		723		146			545		390			585		528	than 1/16 in.
Kerosene.....	690		220		*Bad	685		410		Saturates.	745		510		Saturates.
	*		180		briquette.	500		500			750		490		
	580		250		Saturates.	440		380			825		595		
		605		216			535		430			773		531	
Benzine.....	580		155		Saturates.	610		455		*Bad	640		500		Saturates.
	575		200			*		470		briquette.	600		490		
	710		200			525		465		Saturates.	750		550		
		621		185			567		463			663		502	

SPLICING FOR BENDING MOMENT ALONE.—In the hypothetical girder suggested, let first a web splice at the center be investigated, where the bending moment is a maximum, and the shear is zero, or nearly zero, so that (for stationary symmetrical load) the bending moment only need be considered.

To apply the fundamental formula for flexure,

$$M = \frac{S\,I}{c}$$

in which M = bending moment in inch pounds,
S = unit stress in the outer fiber,
I = moment of inertia of web about neutral axis,
c = distance of outer fiber from neutral surface,

imagine the web plate to be made up of small longitudinal web sections or web elements, for any one of which the sectional area may be denoted by a and the distance from the neutral axis of the girder by d. Then the aggregate moment of the inertia of the cross sections of these elements is

$$M = \frac{S}{c} \Sigma (I_0 + ad^2)$$

the term I_0 being the moment of inertia of any single element around its own gravity axis. If these elements are small, the first term of the parenthesis in this summation becomes negligible, and, very approximately,

$$M = \frac{S}{c} \Sigma ad^2.$$

This formula may be used, for example, to compute the aggregate resisting moment of the elements of the web cross section between rivet holes.

If, next, the value of one rivet in bearing on the web plate is represented by r, the resisting moment of one rivet in any web element will be

$$m = \frac{rd^2}{c}$$

and the resisting moment of all the rivets will be the summation of this expression for all rivets on one side of the splice,

$$M = \Sigma \frac{rd^2}{c}.$$

To get the number of rivets required in any of the web elements, we have now simply to divide the resisting moment of the web element by the respective resisting moment of one rivet, and the result is the following expression:

$$\frac{S}{c} ad^2 \div \frac{rd^2}{c} = \frac{Sa}{r}.$$

This latter formula is seen to be the same as would be used to splice the web for direct longitudinal tension. As the formula contains no factor depending on the distance of the element in question from neutral axis of the girder, it follows that the rivet-spacing throughout the depth of the web will be constant.

Let next the amount of the resisting moment of the web plate be considered. If b = the thickness of the web plate in inches, and h = the depth of the web plate in inches, the fundamental formula for flexure can be written in the following form:

$$M = \frac{S\,I}{c} = \frac{S\,(b\,h)\,h}{6}.$$

From this it is seen that one-sixth of the area of the web plate is to be considered as part of the flange area in resisting moment, but, considering only the lower or tension half of the web plate, and making the splice symmetrical about the neutral axis of the web, it becomes necessary to consider the effect that the rivet holes have in cutting down the area of the web.

The rivets being uniformly spaced and of equal size, it will be seen on reflection that the holes reduce the resisting moment of the web in the same proportion as they reduce the area of the section; that is, the net resisting moment is to the gross resisting moment of the section as the net area is to the gross area. Thus, 1-in. holes spaced 2 ins. on centers give a net resisting moment equal to 50% of the gross moment; on 3-in. centers, 66⅔%; on 4-in. centers, 75%, etc. The relation between size and spacing of rivets and percentage of gross resisting moment developed can be tabulated, and a very simple formula embodying these different relations can then be written which will give the number of rivets required in the web splice. Such a tabulation and formula is shown in Table 1, for 1-in., ⅞-in. and ¾-in. rivets.

The proper spacing to select for any splice depends upon the spacing that will best fit a uniform spacing, upon the total number of rivets required, and upon the number of rows that it is advisable to use. To illustrate the use of this table and formula, suppose that in the hypothetical girder referred to, we had a 108 × ½-in. web plate, and suppose also that our specification held us to the following unit values and conditions:

S = 16,000 lbs. per sq. in.; bearing value of rivets at 21,000 lbs. per sq. in.; ⅞-in. rivets to be used, hence, r = 9,190 lbs.; the full net resisting moment of the web should be developed. At a 4-in. spacing, the number of rivets that can be put in one row equals 108 ÷ 4 = 27. Solving for number of rivets from the formula,

$$n = 0.75\,b\,h\,s \div r$$

we get $n = 0.75 \times 0.5 \times 108 \times 16{,}000 \div 9{,}190 = 70.56$ rivets.

The number of rows equals 70.56 ÷ 27 = 2.6 rows. This shows that a 4-in. spacing is not the best that might be selected, and that it would be better to select a spacing that will fit three rows and thereby develop a greater percentage of the gross area of the web as flange section, or else select a spacing that will fit two rows, and thereby decrease the percentage of the gross area of the web as flange section. Other things being equal, it is always advisable to develop as large a percentage of the gross section of the web as possible. Trying a 4½-in. spacing, the number of rivets that can be put in one row equals 108 ÷ 4.5 = 24. Solving, for n we get, n = 0.778 b h s ÷ r = 73 + rivets. Three rows would contain 3 × 24, or 72 rivets, or about one rivet short of fulfilling the requirement for a 4½-in. uniform spacing. An increase of 1.7% in the unit value for rivets would make n equal to 72, so that for all practical purposes this spacing might be considered as fulfilling the requirement. Trying a 3¼-in. spacing, the number of rivets that can be put in one row equals 108 ÷ 3.25 = 33, or 66 rivets in two rows; n = 0.692 b h s ÷ r = 65 + which shows that the 3¼-in. spacing satisfies the requirement for two rows. The three rows at a 4½-in. spacing develop 13%, and the two rows at 3¼-in. spacing develop 11.5% of the gross area of the web as flange section. These percentages are taken directly from the table.

The choice between three rows and two rows is strictly a question of economy, and has nothing to do with the strength of the net section of the splice. The three rows require 6 more rivets to one side of the splice than the two rows, or 12 more rivets for the whole splice, and also wider splice plates to provide for the extra row. This is an offset to the gain in flange section that the three rows give over the two rows. The rigidity of the specification, in regard to the percentage of the gross area of the web that must be developed, as flange section, might have some bearing in choosing between three rows or two rows. The two rows do not quite develop one-eighth of the gross area of the web as flange section, as many specifications now specify the web must do. In regard to this requirement in the specifications, it would perhaps be better if it read that one-sixth of the net area of the web must be developed as effective flange section.

The width of the vertical legs of the flange angles or flange plates may in some cases call for slight changes from the theoretic uniform spacing of the rivets. Thus, it may be that it is desirable to change the location of the outer rivet from its theoretic location to bring it upon the gage of the angle, generally causing the rivet to be moved closer to the neutral surface. The formula suggested is based upon the theoretic uniform spacing throughout, and since the outer rivets are the most effective, it may be necessary to make a correction for a change in position. Locating a rivet nearer to the neutral surface than its theoretic position causes an increase in the resisting moment of the web plate and a decrease in the resisting moment of the rivet. But this correction rarely is of much importance, as an example will show. With the notation

d = theoretic distance of the rivet from the neutral surface,
d_1 = actual distance of this rivet from the neutral surface,
m = value of a rivet hole, = u b S,
½ h = distance of extreme fiber from neutral surface,
r = value of one rivet in bearing on web plate,
x = number of rivets shifted from d to d_1, which generally is equal to the number of rows of rivets on one side of the splice.

we have

½ $(d^2 - d_1^2)$ m h = increase in resisting moment of tension half of web.
½ $(d - d_1^2)$ r h = decrease in resisting moment of rivets due to shifting one rivet.

If these changes are to be provided for by additional rivets at d_1 from the neutral axis, the required number of additional rivets is

$$\frac{\frac{1}{2}(d^2 - d_1^2)\,m\,h + \frac{1}{2}(d^2 - d_1^2)\,r\,h \times}{\frac{1}{2} d_1^2\,h} = \frac{(d^2 - d_1^2)(m + r\,x)}{d_1^2\,r}$$

Applying this to the above case of a 108 × ½-in. web, with the three rows at a 4½ in. spacing where the outer rivets are 51¾ ins. from the neutral axis, suppose these rivets were shifted 1 in. closer to the neutral axis. If the deficiency in rivet strength caused by this shifting is to be made up by additional rivets in line with the new location of the rivets, i. e., at 50¾ ins. from the neutral axis, the above formula shows that only 0.15 of one rivet would be required.

TABLE I.—Net Moment Capacity of Plate-Girder Webs, and Number of Rivets Required to Splice Web for Moment.

n = number of rivets on one side of splice.
r = resistance of one rivet in bearing on web-plate.
b = thickness of web.
h = depth of web.
S = unit stress in extreme fiber of web (= unit stress in flanges).
p = spacing center to center of rivets in splice.
u = diameter deducted for rivet hole, here taken as diameter of rivet plus ⅛ in.

Formula, $n = \frac{p - u}{p} \frac{bhs}{r}$

Diameter of Rivets.	Diameter of Rivet Holes Deducted.	Uniform Spacing of Rivets.	Per Cent of Gross Area of Web Developed as Flange Sect. ((p-u) ÷ p)⅓%	Per Cent of Gross Resisting Mom. of Web Developed. (p-u) ÷ p	Formula.
u	p				
1"	1⅛"	5.	12.9	77.5	n = 0.775 (bhs ÷ r)
"	"	4.75	12.7	76.3	n = 0.763 (")
"	"	4.5	12.5	75.0	n = 0.750 (")
"	"	4.25	12.3	73.5	n = 0.735 (")
"	"	4.	12.0	71.9	n = 0.719 (")
"	"	3.75	11.7	70.0	n = 0.700 (")
"	"	3.5	11.3	67.9	n = 0.679 (")
"	"	3.25	10.9	65.4	n = 0.654 (")
"	"	3.	10.4	62.5	n = 0.625 (")
⅞"	1"	5.	13.3	80.0	n = 0.800 (")
"	"	4.75	13.2	78.9	n = 0.789 (")
"	"	4.5	13.0	77.8	n = 0.778 (")
"	"	4.25	12.7	76.5	n = 0.765 (")
"	"	4.	12.5	75.0	n = 0.750 (")
"	"	3.75	12.2	73.3	n = 0.733 (")
"	"	3.5	11.9	71.4	n = 0.714 (")
"	"	3.25	11.5	69.2	n = 0.692 (")
"	"	3.	11.1	66.7	n = 0.667 (")
"	"	2.75	10.6	63.6	n = 0.636 (")
¾"	⅞"	4.5	13.4	80.6	n = 0.806 (")
"	"	4.25	13.2	79.4	n = 0.794 (")
"	"	4.	13.0	78.1	n = 0.781 (")
"	"	3.75	12.8	76.7	n = 0.767 (")
"	"	3.5	12.5	75.0	n = 0.750 (")
"	"	3.25	12.2	73.1	n = 0.731 (")
"	"	3.	11.8	70.8	n = 0.708 (")
"	"	2.75	11.4	68.2	n = 0.682 (")
"	"	2.5	10.8	65.0	n = 0.650 (")
"	"	2.25	10.2	61.1	n = 0.611 (")

SPLICING FOR BENDING MOMENT AND SHEAR.—Having considered a web splice at the center of a girder, where it is required to resist bending moment only, it is in order to consider a splice located say at the quarter point, where shear as well as moment must be resisted.

At any point in a beam the actual stress to be considered is the resultant of the shearing stress (acting vertically) and the bending stress (acting horizontally); its numerical value is the

square root of the sum of the squares of these components. Now, the bending stress is maximum at the extreme fiber, and decreases to zero at the neutral axis in linear proportion. On the other hand, the shear, in a rectangular beam, is distributed in parabolic variation, being zero at the extreme fiber and maximum at the neutral fiber, this maximum being 3/2 as great as the average shear found by dividing total shear by area of section. It appears that under these conditions the combined stress, found by determining the resultant of shearing stress and bending stress, has its maximum value either at the neutral fiber or at the outer fiber, depending upon the relative values of the shear and the bending moment. When the average shearing stress (that is, total shear divided by net area of section) is several times as great as the bending stress at the extreme fiber, then the maximum combined stress occurs at the neutral fiber, where it consists simply of the maximum shearing stress, equal to one and one-half times the average shearing stress. Under all other conditions the maximum occurs at the extreme fiber and is equal to the bending stress in that fiber.

In a plate-girder, however, the distribution of shear is not the same as in a rectangular beam. If the value of the shearing stress be calculated for a number of points in the cross section of a plate-girder, and a curve drawn to show its variation from extreme fiber to neutral axis, it will be seen that it is almost constant over a large part of the depth, and begins to decrease rapidly only where the flange begins. Its value at the neutral fiber is, of course, greater than the average shearing stress, but less than 3/2 as great, the ratio in a rectangular beam. At the line of the flange-rivets the shearing stress ordinarily will be well above half the average shear. Under these circumstances the combined stress, that is the resultant of bending stress and shearing stress, will usually have a maximum value a short distance below the extreme fiber. The location and amount of this maximum can only be determined by trial methods in each particular case, but it is quite safe to say that the maximum combined stress will not be greater than the resultant of maximum bending stress and average shear. In girders with relatively heavy flanges, in particular, the web shearing stress at the line of the flange rivets may attain a value very close to the average shear. It will be reasonable, therefore (the slight error involved being on the side of safety), to assume that the shear is uniformly distributed over the section, and that consequently the maximum combined stress occurs at the extreme fiber, where the bending stress is greatest.

Considering again the girder with 108 × ½-in. web, previously mentioned, let it be assumed that at the quarter point this girder has a vertical shear of 5,000 lbs. per sq. in. net section. Assume also that a flange-plate ends at this point, and that this plate is no longer than the theoretically required length; then the bending stress in the flange just at the end of this plate will be the maximum allowed stress, say 15,000 lbs. per sq. in., and the web bending stress of course is the same. On the basis of uniformly-distributed shear the combined stress in the web at the rivet line will then equal

$$\sqrt{15{,}000^2 + 5{,}000^2} = 15{,}800 \text{ lbs. per sq. in.}$$

an increase of about 5% over the allowed stress.

This increase of stress in the web cannot be avoided except by decreasing the actual bending stress below the allowed stress by a compensatory amount. In the above case, suppose the flange section at the point in question be enlarged by 5%, so as to reduce the bending stress to 14,300 lbs. per sq. in.; then the combined stress will be only

$$\sqrt{14{,}300^2 + 5{,}000^2} = 15{,}150 \text{ lbs. per sq. in.}$$

which is within 1% of the allowed fiber stress. Since the points of maximum flange stress in the end sections of a girder are at the ends of the flange-plates, it is only necessary to extend the flange-plates a few rivets beyond their theoretical length, in order to reduce the bending stress in web and flange sufficiently for this purpose.

The behavior of a web-splice in relation to combined stresses will be similar to that of the web itself, provided the rivets are uniformly spaced. It has previously been shown that for bending-moment alone the rivets should be spaced uniformly, and it is clear that the same arrangement is best suited to resist uniformly distributed shear. The inference is justified that the combination of these two stresses requires the same arrangement of rivets as is demanded by either acting independently. The only remaining question is whether the number of rivets needs to be increased, and, if so, how much.

For this purpose it is necessary to consider that point where the resultant stress in the web is greatest, since the load on the rivets will, with uniform spacing, be directly proportional to the web stress. As above, the maximum will be assumed to occur at the extreme rivet, and to consist of the resultant of maximum bending stress with average shear. In the case above computed, the resultant stress was 15,800 lbs. per sq. in., while the bending stress alone was only 15,000 lbs. If a splice occurs at this point of the web, and the riveting was proportioned for the bending stress, then the action of shear will increase the load on the extreme rivet by the same fraction as it increases the web stress, that is, (15,800 — 15,000) ÷ 15,000 = about 5%. This may be compensated for by increasing the number of rivets in the splice a corresponding percentage (or rather a slightly greater percentage because the net area of web will be lessened, which will cause a proportionate increase in the average unit shear and a very slight increase in the bending stress). The additional rivets should, of course, be distributed uniformly along the splice.

It will rarely or never be necessary, however, to increase the splice-rivets on this account, for the following reasons. First, if it is considered permissible to allow a combined stress in the web greater than the specified unit stress, then there should be no objection to allowing a similar excess in the rivet-load, especially as only two or three rivets are affected. Second, a splice will not be affected by the maximum bending stress unless it comes at the end of a flange-plate; it will always be possible to avoid such location, either (1) by shifting the splice or (2) by extending the flange-plate a short distance beyond the splice. This latter in fact should be made a standing rule in designing plate-girders, that is: When a web-splice occurs near the end of a flange-plate, extend the flange-plate over the splice, so as to clear both web and flange portions of the splice.

It is seen, therefore, that if a web-splice has been designed for the net resisting moment of the web (on the basis of full permissible stress in the extreme fiber), and if the splice is sufficient also to resist the shear when acting alone, then the splice will be safe against the combined action of bending and shear.

SPLICE PLATES.—It is the usual practice to use one splice plate on each side of the web plate, the two splice plates together not to be less in thickness than about 1½ times the thickness of the web. The two vertical splice plates can only extend as far as the inner edges of the flanges, and, therefore, additional splice plates over the flanges must be used. These splice plates should extend as close on to the fillet of the flange angles as practicable, and to the inner edges of the angles. The thickness of these plates should be such that the net section of the two plates is at least equal to the net section of that part of the web plate which they are splicing. Usually, the same thickness as the vertical splice plates will be sufficient. Let next the length of these plates be considered. At the center of the girder, where the shear is zero, or nearly zero, and the increment of flange stress consequently is zero or nearly zero, these plates need only be long enough to contain the required number of rivets that are necessary for the web splices. In this connection the splice plates over the flange angles are treated exactly as if they were a part of the vertical splice plates. As we leave the center of the girder, the increment of flange stress, or the amount of stress that the web is transferring to the flanges, is constantly increasing, becoming a maximum at the ends. This increment of flange stress is taken care of by the rivets that pass through the flange angles and web, and consequently, if a web splice is placed anywhere between the center and the end of the girder, those rivets passing through the flange angles on the abutment side of the splice will be performing a double duty. The rivets passing through the flange angles on the side of the splice nearest to the center are not performing this double duty, a fact which can readily be seen if it were momentarily imagined that there was no splice there at all, or if there was an imaginary abutment that took no reaction.

The rivets through the flange angles and the flange portion of the web splice must not be overstrained, and to guard against this the rivet pitch is shortened up enough to allow the necessary space for the rivets required for the splice. Suppose the flange rivet pitch at the splice be designated by the letter p. Let n^1 be the number of rivets required to provide for the splice; let x be the amount that the pitch p can be shortened; and let p^1 be this revised pitch. Also let y be the number of spaces that must be shortened from p to p^1. We then have the following simple formula:

$$y = \frac{n^1\ p^1}{x}.$$

The length of the plates then follows from the spacing of the rivets.

In conclusion, the writer wishes to state that, in any rational design of a splice, the rivets should be located where the stress is, and not where the stress may be assumed to go. Theory calls for a uniform spacing and this spacing will properly take care of the stress. A splice designed according to the principles here explained may be made a standard for any series of girders of the same depth and same vertical width of flange; the only exception being in the splice plates over the flanges, which vary in length and in number of rivets required, according to the increment of flange stress at the position of the splice.

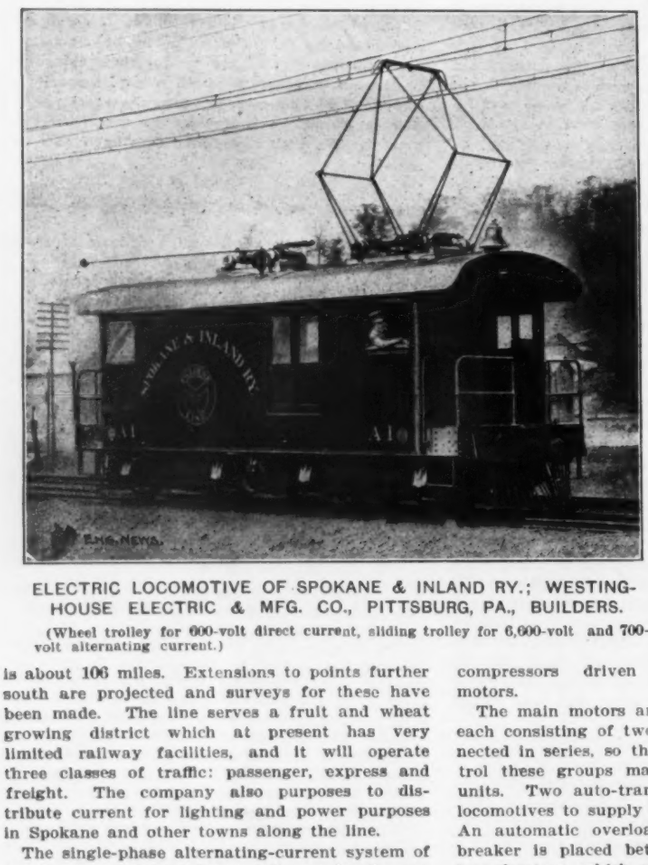
AN EXPOSITION OF SAFETY DEVICES will be held next January in New York City by the American Institute of Social Service. Several expositions have been held in recent years in other countries, with the purpose of exhibiting devices for safeguarding the lives and limbs of working men and women and for preventing accidents to the general public. As an outgrowth of these expositions, a number of permanent "Museums of Security" have been established: at Vienna in 1890; at Amsterdam in 1893; at Munich in 1900; at Berlin in 1901; at Paris in 1905, and recently also at Moscow. In order to ensure the success of this first exposition in the United States of this philanthropic character, the co-operation of manufacturers and of others interested in the improvement of labor conditions, is solicited. Representation may be made by means of photographs, drawings, models, or preferably the devices themselves in operation. Dr. Wm. H. Tolman, of 287 Fourth Ave., New York City, is director of the institute; requests for information regarding space should be made to him.

COMBINATION TIES OF WOOD AND STEEL have been suggested many times and numerous designs have been patented, the purpose being to use only about half or two-thirds as much wood as in the ordinary wooden tie, and also to utilize good pieces of wood which are not long enough to make complete ties. As a rule the design consists of two bearing blocks connected by a steel member. Ties of this kind were used in Holland in 1882, the good portions of old ties being used, and the two blocks being connected by a steel channel. One of the latest designs is that being introduced by the B. H. & B. Combination Tie Co., of Indianapolis, Ind. It consists of two 6 × 8-in. creosoted wood blocks, 3 ft. long, with the top grooved to receive the shallow web of a steel tee-bar 5 × 1¼ ins., 6 ft. long. This is secured to the blocks by screw spikes, and the rails rest upon it, being attached to the blocks by common or screw spikes. A few of these have been put in the track of the Chicago & Western Indiana Ry. The first cost is estimated at about $1.50.

ALTERNATING-CURRENT AND DIRECT-CURRENT TRACTION ON THE SPOKANE & INLAND RY.

One of the most interesting of the many new long-distance interurban electric railways is the Spokane & Inland Ry., a single-phase alternating-current line, which runs south from Spokane, Wash. Electrically it is of special interest among the small but increasing number of single-phase electric railways because it employs three different trolley currents on different sections of the line, namely, 6,600-volt alternating, used in the open country, 700-volt alternating, used in small towns, and 600-volt direct current, used on that portion of the line which is within the Spokane city limits. From the operating viewpoint the railway is noteworthy because it is intended to do a regular freight business as well as passenger.

As now built, the Spokane & Inland Ry. extends from Spokane, Wash., south to Colfax, with a branch to Palouse City; its total length is about 106 miles. Extensions to points further south are projected and surveys for these have been made. The line serves a fruit and wheat growing district which at present has very limited railway facilities, and it will operate three classes of traffic: passenger, express and freight. The company also purposes to distribute current for lighting and power purposes in Spokane and other towns along the line.



ELECTRIC LOCOMOTIVE OF SPOKANE & INLAND RY.; WESTINGHOUSE ELECTRIC & MFG. CO., PITTSBURG, PA., BUILDERS.

(Wheel trolley for 600-volt direct current, sliding trolley for 6,600-volt and 700-volt alternating current.)

The single-phase alternating-current system of traction was adopted because it permits the use of high-trolley-voltage. As the cars enter Spokane over the tracks of the Spokane Traction Co., which employs 600-volt direct current on its trolley-wire, it was necessary to equip the cars also for service on direct current. As is well known, the series single-phase motor is able to run on either direct or alternating current, so that it requires only a special control equipment to fit a car for running over a line having sections of both currents. In the present case, a further advantage was taken of the possibilities of the single-phase motor, by providing also for low voltage alternating current, to be used in the streets of the smaller towns. This avoids on the one hand the undesirable feature of having a 6,600-volt trolley-wire in village streets, and on the other hand the extra first cost and operating expense of a rotary-converter substation for each village.

The power for the line outside of Spokane is purchased from the Washington Water Power Co. The latter's 4,000-volt three-phase current, of a frequency of 60 cycles per second, is transmitted from the generating station by No. 2 copper wires to a frequency-changing station about 10 miles south of Spokane. This station will contain four motor-generator or frequency changing sets, each of 1,000 KW. capacity and composed of three machines on one bed-plate; (1) a 1,000-HP., 60-cycle, three-phase, 4,000-volt induction motor; (2) a 1,000-KW, 25-cycle, 2,200-volt, single-phase revolving-field alternator; (3) a 750-HP., 550-volt, direct-current generator which will work on a storage battery, acting alternately as a motor and a generator. There are three exciter sets for the alternators. The 2,200-volt current is stepped up to 45,000 volts by four oil-insulated water-cooled transformers of 1,250 KW. capacity, and at this pressure is transmitted to 15 substations, each equipped with two 375-KW. transformers which step it down to the trolley line voltage of 6,600 volts. The trolley line is of the catenary type.

The motor cars for passenger and express service have four 100-HP. motors of the single-phase series type, and can maintain a schedule speed of 35 to 40 miles an hour. The electric locomotives for freight service have four motors of 150 HP., and are said to be capable of hauling seven loaded freight cars on level track at 40 miles an hour. The cars and locomotives have wheel trolleys on poles of the ordinary style, for the 600 and 700-volt circuits, and pantagraph trolley frames for the 6,600-volt circuits, the latter being operated by compressed air. The accompanying cut represents one of the freight locomotives with the pantagraph trolley raised. The locomotives are mounted on 38-in. wheels; they are 29 ft. long and weigh 49 tons. The motor cars as well as the locomotives are equipped with multiple-unit control. Both straight and automatic air-brakes are used, with compressors driven by 5-HP. single-phase motors.

The main motors are arranged in two groups, each consisting of two motors permanently connected in series, so that for the purpose of control these groups may be considered as single units. Two auto-transformers are used on the locomotives to supply current to the two groups. An automatic overload and no-voltage circuit-breaker is placed between the trolley and the transformers, which operates on either overload or no-voltage by breaking the current supply to the control magnets, thus automatically opening all the switches. This circuit-breaker must always be closed by hand and it will not stay closed unless the trolley is up and current is on the line. When the circuit-breaker is thrown in, the circuit is completed through the auto-transformers to ground. A commutating switch is automatically shifted to the alternating-current position and the small transformer furnishing current to the control system is cut into circuit, leaving the locomotive ready to start. The alternating current for the operation of the control magnets by the master controller is obtained from the secondary of a small transformer which is connected to the 500-volt point of the main auto-transformer. When operating on direct current a resistance is placed in series with this auxiliary transformer across the 600-volt mains, and direct current is taken from a suitable tap on this resistance. This dispenses with the use of a storage battery for direct-current operation.

The only mechanical operation in changing from alternating current to direct current is to change the trolleys; the control is changed automatically by the commutating switch, which is a small pneumatically operated drum for shifting the control circuits. This drum is operated by a magnet connected directly to a 200-volt tap on the main auto-transformer and has no direct-current connection. The switch has one position for direct-current operation and another for alternating-current operation, and it cannot be thrown to the alternating-current position unless alternating current is flowing through the magnet coil. If it should remain in the direct-current position no harm would be done. The reversing switch is similar to the commutating switch in its operation, but is furnished with two magnets and air cylinders, one for each position.

The Westinghouse Electric & Mfg. Co. of Pittsburg, Pa., has the contract for the entire electric equipment of this railway.

THE WATER SUPPLY AND FIRE-FIGHTING FACILITIES OF PHILADELPHIA, CLEVELAND AND BROOKLYN.

Elaborate reports on the water supply and fire-fighting facilities of the cities of Philadelphia and Cleveland and of the boroughs of Brooklyn and Queens of the city of New York have been issued by the National Board of Fire Underwriters through its Committee of Twenty and its Committee on Fire Prevention. Each report contains a large amount of description and criticism of all the various details pertaining to the municipal water and fire departments, with recommendations for their improvement; some of this material is briefly presented in condensed form in the following.

PHILADELPHIA.—The water supply of Philadelphia is practically inexhaustible, but the pumping machinery is in poor condition and there is no reserve pumping capacity in the more important stations. The pressure in important sections is much too low for good fire protection; in the congested value district it is but 24 lbs. The distributing reservoirs hold only about four days' supply of water. The rate of consumption per capita is excessive. Extensive improvements of the domestic service are now under way.

The fire department is fairly well organized, but its equipment of engines is insufficient in number and of inefficient character. Their pumping capacity is "abnormally low." The fire boat is in defective condition, and the police boat fire-pumps are of only moderate capacity.

CLEVELAND.—The water supply of Cleveland is unlimited, and the pump installation provides a safe reserve. The consumption of water is not excessive, and is decreasing with the installation of meters. However, the pressure in some sections is too low. While most of the main arteries are adequate, the secondary feeders are small, poorly connected and too widely spaced in certain sections. Some of the distributing mains also are too small. Mains for a separate high-pressure fire system are now being laid.

The fire engines are in fair condition but are not sufficiently powerful, and the reserve engines are not reliable. The chemical service is poor, and the supply of hose inadequate. The fire alarm apparatus is of poor construction and unreliable.

BOROUGHS OF BROOKLYN AND QUEENS, NEW YORK CITY.—The water supply of Brooklyn is very deficient, and the reserve pumping capacity of all important stations is inadequate. The distributing reservoirs hold only about two days' supply. The pressure, however, is sufficient for good fire engine supply; in the important sections it averages 40 lbs. The gate valves are too few and in some cases their condition is poor. In Queens also the supply is inadequate, while the pressure is fairly satisfactory; the distribution systems are poor.

The fire engines of both boroughs are of small capacity and many are inefficient. The fire alarm boxes are of undesirable type, and the circuits are frequently overloaded.

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Steel bridges have hitherto monopolized the distinction of being capable of erection without falsework. Now comes a proposal to break this monopoly by erecting reinforced-concrete arches without falsework. The Belvidere bridge, whose noteworthy design and procedure of erection are described on an earlier page of this issue, was not erected in entire accord with this idea, since temporary centering was used for putting in place the "permanent centering," as we may call the arch of concrete form blocks there used. But it will be only a step from this first performance to the complete center-less erection, where the voussoir blocks of the "permanent centering" are held by back stays to make up for the absent arch-thrust until the key-block is in. This method will be directly comparable with the cantilever method of erecting steel bridges. But while the latter is out of the question for ordinary short spans, and is economical only on very long spans, the method proposed for concrete bridges will doubtless be found impossible of use with long spans, and to have its economical application—if it should really prove economical—restricted to short and medium spans.

It is well to note that there is no inherent impossibility of applying a similar method of erection to cut-stone masonry arches, particularly if the design be originally made with a view to facilitating center-less erection. Two or three years ago, in a discussion of masonry arches and their limitations, we heard substantially this method proposed, as a means for dealing with those cases where centering was impracticably costly or impossible. But the proposal seemed visionary in its boldness, and was given little attention.

The destruction of the draw-span of the Duluth-Superior bridge adds a noteworthy instance to the list of draw-bridges wrecked or seriously injured by colliding vessels. The past twelve months have been free from such accidents, so far as we know, and one might fancy that in compensation for this immunity the lot fell this time on a structure remarkable for great length of span and unusually large capacity. In 1905 another important Lake Superior draw-bridge was wrecked in this manner, the draw-span of the bridge over Portage Canal at Houghton, Mich., and the result there was duplicated at Superior: the complete blocking of the channels by the tangle of wrecked steelwork into which the bridge was converted when it fell.

The most striking characteristic of the Duluth-Superior wreck is not so much the length or capacity of the draw as the fact that it blocked the sole entrance and exit of a harbor whose traffic concerns vast interests, and through them the entire country. The harbor ships more iron-ore than any other Lake Superior point, and it must be remembered that Lake Superior furnishes over four-fifths of the country's total iron-ore production. By far the larger part of the harbor's traffic originates in St. Louis Bay, the basin whose sole entrance was crossed by the Interstate bridge. Potentially, therefore, the destruction of the draw-span, blocking the navigation channel, was a commercial disaster, particularly so in the present year of phenomenal demand for iron and steel; the Houghton wreck involved no comparable element of far-reaching importance. Fortunately a chance condition afforded a means for avoiding the indefinitely long blockade which the Duluth-Superior wreck promised. The draw-span was flanked by long fixed spans, and one of these crossed a channel of sufficient depth for navigation. This made it possible to produce a by-pass around the wreck in a relatively short time by lifting off and moving away the fixed span.

It is something of a coincidence that almost exactly a year ago, on Aug. 10, 1905, we drew attention editorially to the fact that collisions of vessels with draw-bridges, while infrequent yet occur often enough to merit consideration in bridge design. At that time, referring directly to the Houghton wreck and a less serious collision at Milwaukee, we suggested that bridge designers have it in their power to minimize the effects of such collisions. We made special mention of the greatest danger involved in the impact of a colliding vessel: the crippling of a main member, which would in most cases result in the fall of the structure; to protect the most exposed member, the lower chord, we suggested the use of some shock-resisting construction for the floor outside the trusses. It is pertinent to note that this very result, the fatal injury to the lower chord, appears to have been the immediate cause of the collapse of the Interstate Bridge. Although there was a roadway with electric car track outside of the truss, in addition to the usual sidewalk, the bow of the colliding vessel was able to crush out a section of the lower chord; with the usual sidewalk alone, it is certain that a much lighter and slower vessel would have been sufficient to accomplish the same serious result. The roadway and sidewalk were of the common plank-floor construction, a type which offers the least possible resistance to the penetration of a vessel's bow. Collision framing or solid flooring in the sidewalk, or better in sidewalk and roadway, would undoubtedly have made a better showing, and conceivably would have saved the bridge.

The resisting quality of concrete when exposed to the action of oil has been for some time in question. Serious deterioration, it has been claimed, is caused in engine and machine foundations, floors of oil storage houses and the like, by the drippings of waste oil to which they are exposed. This assertion, it is true, remained open to doubt among many engineers, who called attention to numerous cases of concrete works which, though long exposed to the action of oil, have remained unaffected. However, experiments carried on in 1903 in the cement testing laboratory of the Chicago, Milwaukee & St. Paul Ry. (Eng. News, March 16, 1905) conclusively demonstrated that, under some circumstances at least, concrete is seriously affected by oil. Just what these conditions are, and how concrete may be so prepared as to be safeguarded against injury of this kind, was not definitely brought out by this investigation, although attempts were made to find a coating or wash that would protect concrete against the deteriorating effect of oils.

Some additional data on the subject are provided by a series of experiments recorded in another column of this issue. These seem to demonstrate, as indeed was suggested in the investigation referred to above, that the thorough setting of concrete forms an important factor in its preservation from the injurious action of oil; this is particularly the case when the concrete is allowed to harden in water. The experiments recorded in this issue, and in 1905, should stimulate further investigation.

The discussion of the construction of brick pavements elsewhere in this issue brings into small compass many sound principles and interesting suggestions regarding a type of pavement that is very much in favor in many parts of the country. As stated in the introduction to the "Instructions," tests of paving brick have received attention by the National Brick Manufacturers' Association. Inasmuch as well made brick are frequently discredited by improper methods of placing them in streets, it is fitting that the National Brick Manufacturers' Association should direct its attention to methods of preparing foundations, laying the brick and filling the joints. The "Instructions" appear to be unusually comprehensive. If they raise discussion at some points where differences of opinion may prevail they will be none the less useful on that account.

BRITISH RAILWAY PRACTICE.

The review of British railway practice which we publish in another column is of more than ordinary interest, reviewing, as it does, the various phases of promotion, construction, equipment and operation. One of its most interesting features is the description of the conditions governing the preliminaries incident to the promotion of new lines, whether by independent parties or by existing companies. A somewhat detailed description of this procedure was given in Engineering News of Aug. 1, 1885. The first thing to be done is to locate the line, definitely and in detail, and to show the location by large-scale plans (not maps) and profiles; a detailed list of individual property to be acquired (with areas and owners) must supplement the plans, and all this information (in lithographed and printed form) is then deposited with the government authorities on a given date each year. It having been decided that the various formalities have been complied with (and failure to comply means that the project is thrown back upon its promoters until another year), then comes the public fight in committee. The promoters strive to show the necessity and advantages of the line; its convenience for the public and its promising financial outlook. The opposition (and unopposed bills are rare) strives to show that the line is unnecessary, will serve no public benefit, will have little traffic, will cost an excessive amount, and will, perhaps, be detrimental to public or private interests, or will be simply a competitor of an existing line already affording ample accommodation. The case may continue for weeks, numerous lawyers being employed on either side, and engineers, real estate dealers, business men, railway officials, and others being called upon for evidence, and being questioned and cross-examined as in a court of law. Much of this is mere "red-tape," it is true, and it also involves very heavy expense, but on the whole there can be no real doubt that the advantages far outweigh the disadvantages of the system. While some wrong decisions are given, permitting the construction of a doubtful line or prohibiting that of a promising one, the main effect is to prevent the establishment of wild-cat lines projected with a view simply to enter into competition with other lines or to benefit the promoters in some way. The road having been authorized, it must be built in accordance with certain very definite rules and regulations of the government authority termed the Board of Trade. One defect of this system is its inflexibility, and this has become more apparent with the completion of a great network of trunk lines and the desirability of opening up the more remote and thinly-settled districts. For branch lines and feeders the cost of undergoing

parliamentary proceedings and complying with Board of Trade regulations is enormous. Some relief was obtained a few years ago by permitting certain projects to be classed as "light railways" and to be submitted to a commission instead of to parliament. For some reason, however, comparatively little use has been made of this practice, and even for "light railways" the Board of Trade regulations appear to be excessively rigorous.

The methods in this country are, of course, entirely different. In general the charter is obtained first, and is secured on payment of a fee and the performance of a few perfunctory formalities, without any chance of objection or opposition. In a few states, it is true, there is a preliminary inquiry as to the purpose, prospects and public benefit of the proposed line. In Massachusetts especially, and more recently in New York, the public interest as affected by new railway construction is carefully considered. It must be borne in mind, however, that the conditions affecting the establishment of systems of control of railway construction were very different in this country from what they were in England. Here, the railways were largely pioneers, extending between and beyond scattered points of settlement, and looking to future development for their traffic and revenues. There was no need of knowing just where the tracks would lie, and little need of protecting against competition, or of specifying details of construction. There, on the other hand, cities and towns were close together, and public and vested interests needed to be protected, so that after the first few years of the uncontrolled "railway mania" the government stepped in and established the system of control and regulation. Now, however, conditions are changing: in England, a relaxation of the severity and expense of the system in certain cases is becoming necessary in order to facilitate the extension of railway accommodation into the agricultural and other districts affording light traffic. The relaxation as to the preliminaries, however, would apply only to the costly "red-tape" methods, as there is no doubt that the inquiry as to the good faith and public benefits of the project should be as carefully conducted for a light railway as for a main line. In the United States there is a growing demand for greater supervision of both construction and operation on the part of the government. As noted above, some states already require projects to be investigated before charters are granted, and with the development of a great network of railways and the closer settling of the country, such a system will become more and more necessary for the protection of land owners and public interests. As far as regulation of operation is concerned, we already have very important requirements as to the equipment of cars with automatic couplers and continuous brakes; the investigation of railway accidents has been commenced within the past two or three years, but at present this is largely statistical, technical inquiries not being made. There is also at present an agitation in favor of the compulsory use of the block system. This is due largely to the number of accidents constantly occurring under the train-dispatcher system, which (with its indeterminate "time interval" instead of an actual "space interval") is not adapted to the safe or efficient handling of heavy traffic under modern conditions.

While the block signal system is compulsory in Great Britain, it is not correct to say (as is said by Mr. Wilson in the article in another column) that "the most perfect form of signaling is demanded." The requirements are for a complete and efficient signal equipment, but for years English railways have been backward in adopting the "lock-and-block" system which is the best safeguard of the manually-operated block signals as used in England. Under ordinary block working there is nothing to prevent a careless or forgetful signalman from lowering a signal to allow a second train to enter a block section before the man at the other end has informed him that the first train has passed out. But with the "lock-and-block" the man at the entrance of one block cannot lower his signal until the apparatus is released by a lock electrically controlled by the other man, so that two men must act in conjunction in order to give a wrong signal. But even then a man has been known to assume that inability to lower a signal merely indicates apparatus out of order, and has given a train hand signals to proceed. As far as automatic signals are concerned, the only argument against them seems to be that manual labor is cheaper than mechanical apparatus. Certainly American main lines with heavy traffic find no difficulty in promptly and efficiently handling such traffic under control of automatic signals. Even that argument does not appear to be very weighty, however, for although switches and interlocking plants (all controlled from signal towers) are much more frequent on English railways, yet for towers which operate only block signals the cost of labor plus the signals and apparatus cannot be materially less than that of the signals and automatic apparatus. The adoption of automatic signaling on the underground rapid-transit lines of London is a sufficient indication of the efficiency of such a system. An objection to the Board of Trade regulations concerning signal equipment is the unreasonable application of these regulations to all railways alike, for (as Mr. Wilson says) "no difference is made between a main trunk line and a small branch line on which only three or four trains per day are run." This rigid rule is, in fact, claimed to be one of the principal causes hindering the construction of light railways and feeder lines.

The immunity from accidents which is frequently claimed as a distinctive feature of English railways is really very much less in degree than is commonly supposed. In fact this immunity (formerly a strong point of English railway operation) is weakening materially, for in recent years the number of accidents, and especially the number of serious accidents, appears to show a marked increase. Broken rails and other defects occur on the much-vaunted track, couplings part, axles and other machinery parts break, and employees show carelessness or disregard of orders. The derailments are due in part no doubt to the great weight of modern locomotives, for although it may be true that "such massive machines as are found on American railways are not possible in Great Britain," it is certain that the modern passenger and freight engines are very much heavier and more powerful than these employed up to a few years ago.

As far as the track construction is concerned, it is doubtful if this possesses a very large factor of safety, in spite of its general reputation for strength. The rails are no heavier than on American lines, they are less frequently supported, and the ties are thinner. On one railway, at least, 86-lb. rails in main track carrying fast and heavy trains are allowed to wear to a weight of only 72 lbs. per yd. before it is considered necessary to renew them; two rail breakages on this road within a short period, one of which caused the derailment of a fast passenger train, indicate that English railway engineers need to give more consideration to the track in its relation to modern equipment and traffic. The engine in the derailment noted above was a 70-ton engine of the 4-4-2 class, with 18½ gross tons on each driving axle. The recent derailment accident at Salisbury (which was discussed in our issue of Aug. 9) was, of course, exceptional in its terribly fatal results, but it is not exceptional in character, being one of many similar accidents of which comparatively little is heard. Some of the English technical papers have been complaining lately at the number of "unexplained accidents," for which the government inspecting engineers have failed to ascertain the cause, and we are inclined to think that in some of these cases an explanation may be found in the condition of the track. The character and number of accidents certainly indicate that steps need to be taken to check their recurrence. From the reports of 12 English accidents occurring within a period of six months, and of sufficient importance to receive [illegible] in the technical papers, we find causes as follows: Seven collisions: (1) Carelessness of engineman; (2) Defective signal apparatus; (3) Wrong signal; (4) Disobedience to signals; (5) Defective method of operating traffic under the block system; (6) Mistake of signalman; (7) Defective practice in signaling. Five derailments: (1) and (2) High speed on defective track; (3) Defective car; (4) Worn rail broke at flaw (11 persons killed); (5) Unexplained.

Referring briefly to some other points touched upon in Mr. Wilson's paper, it may be noted that corridor cars are now extensively used on through trains. These provide the desired separate compartments, but also allow of communication through the train for access to the dining car, smoking compartment, toilet rooms, etc. Sleeping car accommodation is still denied to third-class passengers, being sold only to passengers having first-class tickets. The common type of Pullman sleeping car has never been favored abroad, and is frequently objected to in this country, but only a few American roads are as yet operating compartment sleeping cars. As to large freight cars, these are of 20 to 40 tons capacity, and are employed mainly for the coal and mineral traffic, rather than in regular traffic. Couplings and draft rigging are of very much lighter construction in England than in this country, and there is as yet but little use of continuous brakes on freight trains.

The consolidation of several small car loads at transfer points to form one full load, thus reducing the dead weight ratio and releasing empty cars for service, was, we believe, adopted as the result of investigations made by English railway officers into American methods of handling freight. Only a very few years ago this method was declared by English technical papers to be quite impracticable and of little value.

Mr. Wilson's remarks as to discipline on American railways are erroneous to a very large degree, and it is, of course, absolutely untrue that American employees have no respect for their superiors. Railway employees represent probably as loyal and competent a body of employees as can be found in any occupation, and probably include no larger a proportion of incompetent men than English railway employees. In fact, a glance at the records of English railway accidents show a number of cases of carelessness, such as disregard of signals by enginemen and careless operations on the part of signalmen. Of course in the thinly-settled districts of this country where men are hard to get (and harder to keep) there is bound to be less familiarity with or regard for disciplinary requirements, but there is no doubt that the "railway man" in this country does not suffer in a comparison with those of other countries. One defect which must be admitted, however, is the tendency of some railways to employ unskilled and untrained men (or even boys) in places of responsibility, particularly as operators at stations, transmitting the dispatcher's orders to the trains. Several serious accidents are directly attributable to this practice, the men forgetting orders or making mistakes in them. Still, even in England, such a practice is not unknown, as revealed by the accident records. The one advantage of English railways in regard to their employees is that the men are more permanently employed, and more content to remain permanently in one position, while in this country most men are continually on the outlook for something better, whether in their present occupation or in some new kind of employment.

THE PRICE OF GAS IN WALSALL, ENGLAND, has been reduced in the case of manufacturers from 54 cts. to 48 cts. per 1,000 cu. ft. The Birmingham city authorities a short time ago similarly reduced the price to 38 cts. Throughout this section of England, according to a consular report, there is an increased use of gas for power purposes, and at the same time a greater determination on the part of gas companies, whether private or municipal, to meet the competition of the producer gas engine plant.

LETTERS TO THE EDITOR.

Protection Against Loss from Unexpectedly Long Overhaul.

Sir: I am troubled with the question of long haul in wheeler work on railroad construction and would like a remedy in the form of a clause to insert in a contract which will protect a contractor from loss due to excessive hauls made necessary by a narrow right-of-way of 50 ft.

Suppose a sub-contractor with only a few teams and only scraps and wheelers took on a piece of work which showed mostly "borrow;" and after he had moved on the work the grade line would be changed so that the "cuts" would make the "fills."

This has been done either to reduce maximum grade or to save having too long additional right-of-way for "borrow" and in these times of high prices (20 to 25 cts. per cu. yd. for earth) with a 500-ft. free haul and the usual 1 ct. per cu. yd. per 100 ft. afterwards, the contractor would have to haul from 2,500 ft. to 3,000 ft. extreme haul. He cannot do it for the price—and next year he is working for some one else by the day.

I would like to hear of some arrangement which would be fair to the contractor and which ought to be acceptable to any fair-minded chief engineer or general manager.

Yours truly,

Contractor.

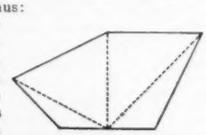
Iowa, Aug. 18, 1906.

On Computing Areas of Cross-Sections.

Sir: In your issue of Aug. 16 Mr. Elbert O. Brower asks for an expression of opinion as to the value of his formula for computing areas of cross-sections of railroad embankments and excavations. I rather expected that you would have pointed out the fact that a much simpler formula is in common use on practically all railroad work in this country, namely, the following:

Area = (¾ width of roadbed × sum of side heights) + (½ center height × sum of distances out from center to side stakes)

derived as is easily seen from the division of the cross-section into four triangles, thus:



Mathematics is a beautiful science, but the average man taking cross-sections at the rate of a mile or two a day, and setting slope stakes with the contractor at his heels, would drop dead if he thought he had to figure his quantities by Mr. Brower's formula after he got back to camp at night.

There have been several intricate mathematical solutions of simple problems published in your columns recently, especially those relating to so-called special curve problems. It would almost seem that if it were really necessary to publish these specimens of mathematical fireworks, that there should be a note to that effect, so that those who really have actual work to do might not be misled.

Yours very truly, F. Lavis.

The Welland Canal and the Deepening of the New York Barge Canal.

Sir: I read with interest your editorial discussions of the enlargement of the Erie Canal and all of the arguments by the various correspondents, covering the capacity of the waterway and the location by lake or inland three years ago.

I am now interested to a greater extent than formerly, as I have been stationed on the border of the Welland Canal for the past ten months. In your article in the Engineering News of July 26, 1906, appear the preamble and resolution of the Advisory Board of Engineers. Article second of the preamble states that "the Canadian system of canals from Lake Erie to Montreal has a depth of 14 ft. and locks 45 ft. wide."

During my residence in Welland I have learned that the headgates of the Welland Canal at Port Colborne have been rebuilt for a depth of 16½ ft. The big rock cut a few miles north of Port Colborne gives a depth of water of 20 ft. I understand that at no place between Port Colborne and Welland is there a less depth of water at the present time than 18 ft. At the "Aqueduct," where the canal crosses the Welland River, there is a depth of only 14 ft.

Government engineers have been making surveys for the past six months, and prominent Canadians freely express the opinion that the canal will shortly be improved, giving a minimum depth of about 22 ft. This can be accomplished with comparative ease and no excessive expense, except at the crossing of the Welland River. The "Aqueduct" at this point was a difficult piece of construction, and is said to have cost the government about $3,000,000. To secure 20 or 22 ft. of water would be a great but expensive undertaking.

From what I can learn of the desires of the Canadian people and the intentions of the government, I am of opinion that within five or ten years the Welland Canal will be improved so that boats drawing 20 and perhaps 22 ft. of water can pass from Lake Erie to Lake Ontario; and before the expiration of a second like period the Lachine system will also be able to pass the same vessels. When this occurs the Erie Canal, with its 12 ft. of water, will be out of date, and the ship canal connecting the Hudson River with Lake Ontario, which was so ably advocated during the discussions three years ago, will be a necessity.

William P. Snow.

Welland, Ont., Aug. 3, 1906.

Concerning the Ramsey Crank Mechanism.

Sir: I am surprised to read in your article (Vol. LVI., No. 7, p. 178) on the Ramsey crank mechanism for gas engines that novelty and patents are claimed in connection with this device. Mr. Chas. E. Duryea, the well-known gas engine expert, has advocated offsetting the crank for years, and in the engines of the Duryea automobiles the cranks have been offset at least five years.

Respectfully,

Harvey Feldmeier, C. E.

Little Falls, N. Y., Aug. 18, 1906.

[Following is the reply of the Ramsey Engine Co. to our letter asking that they note the difference between their device and Mr. Duryea's.—Ed.]

Sir: The Ramsey crank mechanism differs from the device advocated by Mr. Charles E. Duryea, and used in the Duryea automobile, just as it differs from the Nash, the Mors, the Westinghouse and various other engines that have made use of the advantages to be obtained by offsetting the crank shaft to a greater or less degree. The idea of offsetting the crank shaft from the center line of the cylinder is not in itself a new one, and at various times manufacturers have brought out engines with the crank shaft offset a distance equal to some fraction of the length of the crank. The Ramsey crank mechanism differs from all of these devices in that it combines with a shaft offset from the center line of the cylinder a distance equal to the full length of the crank, the use of a connecting rod only 3⅜ times the length of the crank, instead of five times, as is the ordinary practice. In other words, the patents of the Ramsey Engine Co. cover the use of a connecting rod less than four times the length of the crank, used in conjunction with a cylinder so arranged that the center line of the cylinder is approximately tangential to the path of the crank on its outward stroke.

It is to be noted, therefore, that while the use of the offset crank shaft will reduce the cylinder friction to a considerable degree, it is only when used in conjunction with the shorter connecting rod that the further benefits of the Ramsey crank mechanism are obtained. The increased length of piston stroke, and the greater effective crank travel, with the resulting increased efficiency; the sluggish movement at the end of the stroke, allowing time for free exhaust; the quick compression, and the reduction in weight; all of which are characteristic of the Ramsey crank mechanism, are not to be obtained except by means of the combination described. It is to these other elements as well as to the decreased friction, that the Ramsey crank mechanism owes its remarkable efficiency.

Very truly yours,

Ramsey Engine Co.,

R. H. Eisenbrey, Secy and Treas.

Philadelphia, Pa., Aug. 23, 1906.

On the Design of Reinforced Concrete Beams.

Sir: I was very much interested in Mr. Godfrey's article on the "Design of Concrete Steel Beams and Slabs," which appeared in your issue of March 15, 1906.

The formula for the total moment, $M = 354\ B\ D^2$, seems to the writer to be slightly in error. In any cross-section of a beam, the sum of the direct stresses in compression must equal the sum of the direct stresses in tension, as the algebraic sum of the horizontal components must equal zero. Further, for a symmetrical section, it would seem to be necessary that the sum of the moments on the convex side of the neutral axis be equal to the sum of the moments on the concave side, assuming the neutral axis to pass through the center of gravity of the forces. This result will be obtained by taking the neutral axis $^1/_{40}$ of the depth of the beam below the center of the section.

For, if the steel be one-eighth of the depth above the bottom of the concrete, and if x be the distance from top of beam to neutral axis, then the moment of the compressive stresses about the neutral axis is

$$\tfrac{1}{2}\ b\ S_c\ x \times \tfrac{2}{3}\ x = \tfrac{1}{3}\ b\ S_c\ x^2,$$

and the moment of the tension in the steel (considering that the concrete carries no tension) is $S_s\ A_s\ (\frac{7}{8}\ h - x)$. Equating these moments and putting the total tension $S_s\ A_s$ equal to the total compression $\frac{1}{2}\ b\ S_c\ x$, gives $x = {}^{21}/_{40}\ h$, or the neutral axis is one-fortieth of the depth below the center, as stated.

The formula then becomes, $M = 367.5\ B\ D^2$. There will be required slightly more steel, according to Mr. Godfrey's unit values, than he gives, namely, 1.3125% instead of 1.25%.

By making these changes, the mathematical conditions are satisfied, assuming that the neutral axis remains near the middle of the beam, which is one of Mr. Godfrey's premises.

The writer would be pleased to see the opinion of others on this one point in particular.

Yours very truly,

W. H. Sadler, Asst. Engr.

Plattsburgh, N. Y., Aug. 20, 1906.

[We know of no principle of mechanics that requires the moment of tensile stresses on any cross section of a beam to equal the moment of the compressive stresses, taking moments about the neutral axis. Nor do we know of any reason that would make it desirable to proportion a beam so as to produce this equality. It need hardly be observed, of course, that in a reinforced-concrete beam the term "symmetrical section" means nothing without special definition.—Ed.]

Coal Tar Paints!

Sir: Referring to the comments in your issue of Aug. 17 on my letter on Coal Tar Paints, I would state that the labor expense in painting is seldom a minor element in the cost, but even though the labor cost nothing, it still wou'd be expensive to use a paint made from tar as against a good quality of iron oxide paint made with pure linseed oil. The tar paint would cost at the lowest 30 cts. per gal. in barrels, and usually costs nearer 50 cts. (I am presuming, of course, that you do not figure on the consumer making his tar paint, as it requires some experience to make even such a paint), while a first quality pure linseed oil oxide of iron paint can be purchased at 70 to 75 cts. per gal., and one gallon of this will cover over twice the surface that a gallon of tar paint will cover, and can be applied in half the time, and the durability as regards sun exposure will be from eight to ten times longer.

Mr. Cunningham is in error in thinking that I was referring solely to raw coal tar. What I intended to convey was that there is no method of successfully treating coal tar, oil tar, pitch, asphaltum, gilsonite, or any similar product that will make them into suitable pigments to use in a paint that will be durable when exposed to the sun; while after proper treatment they do make very durable paints for underground or underwater exposure.

With regard to boiled oil,. it is not because genuine boiled oil is a thing of the past that we no longer use it. It would be a simple matter to kettle-boil the oil ourselves if we thought kettle-boiled oil was better to use than raw oil, but it is a conceded fact that genuine boiled oil does not have the same durability as first quality raw linseed oil in connection with the proper drier.

As to red lead, Mr. Cunningham's experiments only prove what we have stated in print for years (see page 12 of our "Technical Paints for Metal"), and that is, that 50% to 80% of red lead used with a selected pigment will give better results than using 100% of red lead, only he made the error of using zinc oxide when he might have used an inert pigment like graphite or an English oxide of iron.

Red lead paints, when properly made, do have the support of the paint maker, and thousands of gallons are made and sold every month by them. If Mr. Cunningham can produce a coal tar paint that will be durable in the sun, it will not be out of our sphere to manufacture it, and as he states that it must undergo a treatment, we take it for granted that the average consumer will not be equipped to make it properly, hence there would be room for us and other paint makers. We did not understand, however, from Mr. Cunningham's article that he had tested this paint for sun exposure, but that he had found it of service under water, and that you had drawn from that the conclusion that if it stood under water it would be durable in any location, hence suggested the use of it on roofs and sidings; we know it will not stand that kind of exposure, neither would it be a cheap paint to use, hence our protest.

If Mr. Cunningham is a member of the American Society for Testing Material we would be very glad to have him take this matter up with the society (of which we are members), and we would gladly contribute towards having a test made under the direction of the society.

Yours truly,

F. P. Cheesman.

100 William St., New York City, Aug. 23, 1906.

Notes and Queries.

The Allis-Chalmers Co.'s shop extensions at West Allis (Milwaukee), Wis., were described in our issue of July 12. The contractors for the steel work were mentioned, but we are informed that James Stewart & Co., of Pittsburg, Pa., were the general contractors.

THE CONSTRUCTION OF BRICK PAVEMENTS.

The investigations and tests of the quality and properties of paving brick which have been carried out extensively on a systematic and scientific basis for a number of years, have resulted in greatly improving the efficiency of brick as a paving material. Another line of investigation, however, now seems to be necessary or desirable, and that is in regard to the proper construction of brick pavements. Cases of the failure of brick paving have been reported, in which the real cause was the character of construction of the pavement, although the blame was laid upon the brick itself, which therefore acquired a reputation of being unsuitable for paving purposes. The National Brickmakers' Association has co-operated extensively with the work of formulating standard tests of paving brick, with a view to improving their quality, and consequently tending to increase their use. The best bricks, however, will not give good results if improperly laid, and as brick paving is extensively used in the smaller towns, and often receives only a small amount of engineering attention, there are many cases in which the construction is not such as to allow the brick to show to advantage. The work is also liable to be done under insufficient or faulty specifications. With these conditions in view, and with the work of the National Brickmakers' Association as a precedent, the National Paving Brick Manufacturers' Association has taken up the matter of the proper construction of brick paving, and has had prepared a series of general principles and instructions which it believes should be incorporated in specifications for this class of work in order to insure a good and reliable and economical pavement. Copies of these may be obtained on application to Mr. W. J. Blair, Secretary of the National Paving Brick Manufacturers' Association, at Terre Haute, Ind. We give below an abstract of some of the special features, and may call attention to the fact that nothing is said concerning the use of pitch or asphalt fillers for grouting the brick, cement filler only being specified. The portions of the text set "solid" are, as may be inferred, explanatory. The matter quoted is as follows:

INSTRUCTIONS FOR LAYING BRICK PAVEMENT.

GRADING.—Earth in excavation to be removed with plow and scraper, or other device, to within 2 ins. of subgrade, then brought to the true grade with the roller, the weight of which should not be less than five nor more than eight tons. If the earth is too hard to receive compression through the roller, then loosen the 2 ins. with a pick and remove the material. Earth in embankment must be applied in layers 8 ins. thick, each layer being thoroughly rolled. In both excavation and embankment the subgrade must have a uniform density. If the ground is wet clay, tile drainage should be provided to carry off the accumulation of water.

The attempt to remove earth to the proper depth or grade line with plow and scraper is usually fatal to the general surface of the subgrade, for the reason that no man can hold a plow (or team draw the same) to a straight grade. Therefore in an attempt to get too close to subgrade with a plow, holes will be gouged below the true grade. When the shovelers commence the removal of the plowed earth, they will invariably sink these places still lower, and when the finishing begins these low places will have to be filled and compacted with the roller. The result is a varying degree of solidity, which is detrimental to good work. The prime reason for not using a roller weighing more than eight tons is that they are cumbersome and slow moving, while the lighter and quicker roller will pass many times over the subgrade and so give better results in having the subgrade more uniformly compacted.

CURBING.—Stone curbing should all be hauled, distributed and set before the grading is finished, and may then be used as a guide to finish the subgrade. It should range in thickness from 4 to 6 ins. and in width from 20 to 36 ins. (according to the business and street traffic), the lengths should be not less than 4 ft., except at closures. Neatly dressed on top, with a square or rounded edge, and dressed 4 ins. down on the inside. The outer surface to be tool-dressed to the depth of the face exposed and to the depth of the thickness of the brick and sand cushion. If concrete curb is used, it should be completed before the work of finishing the subgrade begins. The curb corners of streets and alleys should be made circular.

If concrete curb and gutter is used, it must be placed in position before any of the other work is commenced, except, possibly, some of the heavier grading. If natural stone curb is used it is essential to have it all in place before any portion of the grading is finished, for the reason that after the subgrade is finished to the proper contour and surface it should never be disturbed by unnecessary wheelage, and nothing destroys it so effectually as hauling heavy stone curb over it. In renewing these broken places they are rarely returned to the original conditions. The curb should all be set before the finishing of the subgrade begins, if for no other reason than that it affords the best guide for the finishing.

MARGINAL CURB.—This should always be of a hard and durable character of stone, 14 to 18 ins. deep, dressed on top, and 5 ins. down on the face next to the brick. Set to accurately fit the curvature of the cross-section of the street on 6 ins. of concrete and backed up with the same within 6 ins. of the top. Use a Portland cement concrete in proportions of 1-2-4.

Marginal curb is as a rule used to sustain a paved street against one that is unpaved; therefore unless it is well and properly set the impact of the wheels in passing from the unpaved to the paved street, will soon drive it down and loosen it and the pavement will break and give way. Even with the marginal curb set in the above manner there should be a margin of crushed stone or clean gravel to the width of 3 or 4 ft. and 8 or 10 ins. deep spanning the width of the opposing unpaved street and tamped firmly against the marginal curb.

CONCRETE FOUNDATION.—The concrete should be made with hard rock, free from all refuse and foreign matter, with no fragments larger than will pass through a 2-in. ring, and none smaller than will pass through a 1-in. ring in their longest dimensions. Clean, sharp, dry sand should be thoroughly mixed in its dry state with an approved brand of either hydraulic or Portland cement until the whole mass shows an even shade. With hydraulic cement, the proportions should be 1 cement and 2 sand. With Portland cement, 1 cement to 3 sand. To the above mixture should be added sufficient clean water to form a plastic mass, fluid enough to rapidly subside when attempting to heap it into a cone shape. To this mixture add four or six parts, respectively, of damp crushed stone, or good gravel carrying sufficient sand to make the mixture, and turn the whole mass over not less than three times, or until every fragment is thoroughly coated with the cement mixture. For the reception of this mixture, the grade should be set off in 5-ft. squares, with a stake at each corner. The concrete must be tamped until free mortar appears at the surface. Occasional sprinkling in extra hot, dry weather is beneficial. After 36 hours the cushion sand may be spread.

If the combination of gravel and sand is used the mixture for natural cement should be 1 measure of cement to 6 of the mixture. If Portland cement, 1 measure of cement to 8 of the mixture. It is essential that the sand and cement should be thoroughly incorporated in the dry state; if not, then it cannot be done after the water is applied. The above applies especially to platform mixing. In machine manipulation the dry mixing is not so readily obtainable, but could be more nearly approached if greater care were taken.

SAND CUSHION.—The sand should be clean and free from foreign or loamy matter, but need not be sharp. It should be 2 ins. thick before the compression of the brick by rolling. The sand should be spread by the aid of a template the whole or half the width of the street.

The template should be formed to the curvature of the street and fitted with small metal wheels at either end, rolling on the curb at one end and on a 4 × 4-in. scantling laid lengthwise through the center of the street at the other. If the width of roadway of the street is not over 25 ft. the template can be made to span the entire width, both ends rolling on the curbs.

BRICK.—The paving brick should be first-class and thoroughly vitrified, showing at least one fairly straight face; if with rounded edges, with no greater radius than $^{8}/_{16}$-in. They should not be less than 2¼ × 4 × 8 ins. or more than 3½ × 4 × 9½ ins., free from cracks, with but slight lamination, and at least one edge with but slight kiln marks allowed. They should stand the tests prescribed by the National Brick Makers' Association.

The brick should all be hauled and neatly piled within the curb line before the grading is finished, or (if allowed by the engineer) delivered in wagons and carried from the pile or wagon on pallets with clamps—not wheeled with barrows. In hauling from the car no throwing or dumping is allowed.

It is very expensive to attempt to get brick into a block after the other work has begun. Each side of the street should have the required number of brick neatly ricked up to lay to the center of the street, thereby always maintaining the minimum distance to carry the brick to the setter. In order to get the brick to the setter with the least possible abrasion or injury, it is best to carry them on pallets, and so deposit them that the person laying them in the street will deposit them face edge up. No wheeling or teaming should be permitted over the brick at any stage prior to opening the same to the public.

LAYING BRICK.—The brick may be laid either at a right angle or at an angle 45° to the curb, as the engineer may direct, and in either way the line or course of brick must be kept straight or within a maximum variation of 2 ins. No parts of brick should be allowed in the pavement except the beginning or ending of courses or other closures. The brick must be laid with the best edges exposed, as near in contact as possible; they must be closely inspected before laying and also after laying and after rolling. All soft or badly spalled or ill-shaped brick must be removed and replaced with perfect ones. The kiln-marked bricks may be turned over, and if the reverse edge is smooth and no other faults be found, they may remain in the pavement.

The brick should be as nearly in contact as it [illegible] ble to lay them, for when the rolling is in pr[illegible] there is appreciable space between them in [illegible] pression and bedding into the cushion sand, [illegible] will have a tendency to rock, and instead of [illegible] a flat foundation, as they should, it will be in [illegible] form, made by the rocking of the brick as [illegible] passes on and off of them, and the pavement wi[illegible] more grout to fill the interstices. If the gutter [illegible] very flat, five or six longitudinal courses may [illegible] parallel with the curb, as there will be less hind[illegible] the gutter drainage.

ROLLING AND TAMPING.—After the brick [illegible] pavement are inspected and the surface is swept [illegible] of spalls, they must be well rolled with a 5-to[illegible] roller. The brick next the curb should first be [illegible] with a hand wood tamper to the proper gutter gr[illegible] The rolling will then commence near the curb at a v[illegible] pace and continue back and forth until the cente[illegible] the pavement is reached, then pass to the opposite c[illegible] and repeat in the same manner to the center of the [illegible] After this first passage of the roller the pace [illegible] be quickened and the rolling continued until each [illegible] is firmly embedded in the sand cushion. The roll[illegible] shall then be started at the end of the block and the pa[illegible] rolled transversely at an angle of 45° to the [illegible] of the block; repeat the rolling in like manner in the [illegible] site direction. Before this transverse rolling takes [illegible] all broken or injured brick must be taken up and re[illegible] placed with perfect brick.

The use of a steam roller on a brick pavement is very necessary in order to give it a smooth surface. The transverse rolling is necessary in order to remove the slight wavy condition of the surface, extending laterally from curb to curb, which will occur after the longitudinal rolling. The longitudinal rolling should always be from curb toward the center. The curved transverse section of the street has a tendency to move the brick endwise toward the curb; therefore, if the roller is started in the middle and works toward the curb the gutter bricks previously tamped to grade will be disturbed. If it were practicable to use the roller absolutely against the curb the rolling might be done from the center to the curb.

EXPANSION CUSHION.—A 1-in. expansion cushion must be provided next to the curb, filled two-thirds of its depth with pitch, the top one-third being filled with sand.

This pitch joint along the curb answers two purposes; it takes up the expansion of the brick and prevents a possible cracking of the pavement through and along the center of the street, which sometimes occurs if the ends of the courses of the brick are abutted directly against the curb which acts as a skewback and is often strong enough (especially if the sidewalk is up to and against the inside of the curb) to resist the force of expansion in that direction and it will find relief in raising the pavement and the cracking mentioned above may occur. In taking up the expansion, the brick are kept in contact with the sand cushion below, thereby preventing the rumbling noise so often heard, and occasioned through lack of contact. The sand on top of the pitch joint has a tendency to prevent the pitch from flowing in very hot weather. The board occupying the place to be filled with pitch must remain in place until after the street is in all other respects finished, but always withdrawn and the pitch applied within 36 hours after the application of the cement filler.

FILLER.—The filler shall be composed of one part each of clean, dry sand and Portland cement. The mixture, not exceeding ½ bushel of each material, must be placed in the box and mixed dry, until the mass assumes an even and unbroken shade. Then water shall be added, forming a liquid mixture of the consistency of thin cream. From the time the water is applied until the last drop is removed and floated into the joints of the brick pavement, the mixture must be kept in constant motion.

The mixture should be removed from the box to the street surface with a scoop shovel, all the while being stirred in the box as the same is being thus emptied. The box for this purpose shall be 3½ to 4 ft. long, 27 to 30 ins. wide and 14 ins. deep, resting on legs or different lengths, so that the mixture will readily flow to the lower corner of the box, which should be from 8 to 10 ins. above the pavement. This mixture, from the moment it touches the brick, must be thoroughly swept into the joints.

Two such boxes should be provided in case the street is 20 ft. or less in width; or three boxes if the width is over 20 ft. The work of filling should thus be carried forward in line until an advance of 45 to 60 ft. has been made, when the same force and appliances should be turned back and cover the same space in like manner, except to make the proportions two-thirds Portland cement and one-third sand. To avoid the possibility of the thickening at any point, there should be a man with a sprinkling can (the head perforated with small holes) sprinkling gently the surface ahead of the sweepers.

Within half to three-quarters of an hour after this last coat is applied, when the grout between the joints has fully subsided and the initial set is taking place, the whole surface must be slightly sprinkled and all surplus mixture left on the tops of the bricks swept into the joints, bringing them up flush and full. After the joints are thus filled flush, and sufficient time for evaporation has taken place, so that the coating of sand will not absorb any moisture from the cement mixture, a ½-in. bed of sand should be spread over the whole surface. In case the work is subjected to a hot summer sun, an occasional sprinkling, sufficient to dampen the sand, should be followed for two or three days.

The first application should be thin in order that it may flow to the depth of the joints of the bricks, thereby insuring a substantial bond, and should be kept in constant motion while being applied, otherwise the sand will settle. It must also be mixed in small quantities, as otherwise it is next to impossible to keep the sand in suspension. If we could get the sand in the lower, and the cement in the upper portion of said joints, it would make a well-grouted street. Some one may perfect a mechanical device for doing this satisfactorily, but at this time no such method is known. The rocking trough has been tried for the mixing and discharging, but invariably the cement and water will flow out first, then follows the sand to fill the upper parts of the joints. Therefore, the safest way is to use the scoop shovel as directed. Ten days is the minimum time for keeping the street blockaded and free from traffic; 30 days (or even more) would be better.

Some additional comments upon requirements and specifications for brick paving have been sent to us by Mr. Blair in further explanation of the reasons why some brick-paved streets are satisfactory and others are unsatisfactory. The aim of the National Association of Paving Brick Manufacturers is to furnish such directions for building brick paved streets as will eliminate unsatisfactory results. These comments are supplementary to the directions already given, and will be of interest to engineers engaged in municipal work:

The reasons why there are cases of brick streets proving unsatisfactory are largely due to the fact that the specifications under which they are constructed are not right; some directions are omitted that are vital to proper construction. The subgrade is usually fairly well prepared and the specifications therefor are usually well written. The mixture of the concrete base is also fairly well provided for in regard to proportion and method of mixture.

The first vital point is that very often the specifications do not require the surface of the concrete base to conform to the grade of the finished street. Even to state in the specifications that this must be the case is not sufficient, but the engineer must provide the means by which the contractor can meet the requirements. The proper method is for the engineer to give stakes at intervals of 4 to 5 ft. each way and to remain upon the work while it is being executed in order to give the necessary information. The curb of the street, if used for a guide, gets out of its correct shape by so small an accident that only the work of the engineer can be depended upon to assure this true grade. If this is not done, there will be slight depressions in the pavement to destroy its appearance and to hold water.

This true grade is equally important to ensure the uniformity of the 2-in. sand cushion. Many specifications do not require this thickness, but if only a 1-in. cushion is used the life of the pavement will be reduced perhaps one-half. The deflection can not be properly relieved and the brick are required, therefore, to develop a greater resistance to the impact than is at all necessary. The rolling of the brick to compact them into this 2-in. cushion, and incidentally to compact the cushion itself, is a matter to which very often no great importance seems to be attached, and yet it is a matter which is vital to the durability of the street. If the cushion is not thoroughly compacted, or the brick is not compacted into the cushion, reducing the deflection to a minimum, then the strength and the durability of the brick pavement rests wholly with the brick and the cement filler which binds them together.

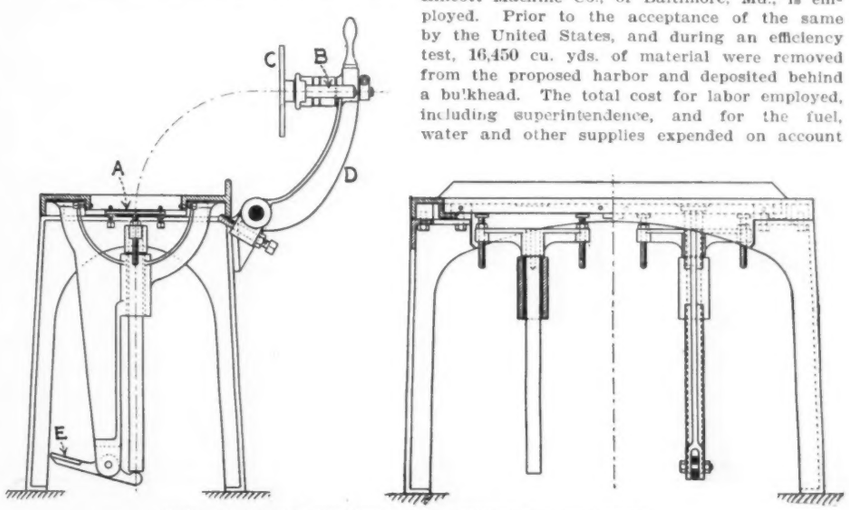
As to the cement filler, this is a most important feature. The cement must be of a very high grade, mixed in the proportion of 66% cement and 33% sand, and laid in compliance with the directions given in the specifications. It often happens that no attention is given either by specification or by way of enforcing skillful work to insure the brick being placed in the street face edge up. In many other cases no due regard is paid to the necessity of an expansion cushion along the edge of the curb; it is rarely put in correctly and frequently omitted altogether. But it is attention to these small details that goes to secure the perfect brick street.

The writer recently observed a gang of five workmen applying the cement filler to a brick street in a town where the frontage, exclusive of the buildings, was worth $1,000 per front ft. No engineer was near, and there was no responsible foreman in charge. The gang was equipped with a box 3 × 6 ft., 10 ins. deep, with strong handles at the four corners. The men dumped into the box a package of cement and a wheelbarrow of sand with so much soil in it and so few sharp grains that it alone would make the mixture worthless. The sand was wet before it went into the box, which was another objection. The quantity received less than a dozen strokes with the hoe instead of a complete mixing to bring it to a uniform color. After the water was applied, the mixture was stirred with two hoes which were then leisurely laid aside and the box containing the mixture slowly overturned, spilling the mixture upon the street. As a result, the bond was broken as soon as the street was opened for traffic, and the brick were loose in the street. The details in the construction of the street from beginning to end, were like those of the application of the cement filler.

The quality of the brick furnished for this street were of the very best, and the engineer subjected the brick to all kinds of known tests to determine their quality, but when that was done, his work seemed to be at an end.

REINFORCED CONCRETE SHINGLES FOR ROOFING.

One of the numerous applications of cement and concrete to the manufacture of building material is that of shingles for roofing. Special machines (operated by hand or by power) are being built by Wickes Bros., of Saginaw, Mich., for the manufacture of such shingles. These machines make not only the plain shingles but also those for hips and ridges, etc., and all of them have steel reinforcement, which prevents their falling to pieces even if they should crack. The accompanying cut shows a cross section of the hand machine, which makes two shingles at each stroke. Two or three reinforcing wires are set in place lengthwise, also the nailing loops and eyes (fitting recesses in the mold). The mold at A is then filled with concrete. This is tamped by means of the handles B on the tamping plate C, carried by the hinged bar D, and pressure on the treadle E then raises the pallet clear of the



HAND MOLDING MACHINE FOR CONCRETE SHINGLES.

mold. The shingle is then removed with the pallet and placed on a rack for at least 24 hours.

The power machine is for continuous operation and has a long table at each end, the entire length being about 45 ft. A belt, conveyor chain and sprockets extend the entire length of the table so as to make a continuous loop of molds. At the entering end a boy places a pallet in the mold and covers it with a piece of tissue paper to prevent the concrete from adhering to the pallet. Another boy sets the reinforcement in place. As the mold passes under a hopper the proper amount of concrete is dropped into it and is tamped as the mold passes under the tamping rolls of the machine. Beyond these are five trowels which smooth and glaze the surface of the shingle. The mold then travels along the delivery table, where a boy removes the pallet and shingle and sets them on a rack, while the mold travels back to the head of the machine.

The plain shingles are 8 × 16 ins., ½ in. thick at the butt and tapering slightly towards the top. They may be of various shapes and of any desired color. The concrete is composed of 1 part of Portland cement to 2½ parts of clean, sharp sand; these are mixed dry, and water is then added to make a stiff paste. The steel reinforcement may be of copper or galvanized steel wire, No. 16 for the transverse pieces and No. 20 for the lengthwise pieces and the loops at each side through which the nails are driven. The shingles must remain on the pallets for at least 24 hours; they are then carefully removed to the yard racks where they are kept for about a month, being kept moist by sprinkling during the first few days. The shingles are not fastened rigidly to the roof, so as to allow for contraction and expansion and for the action of ice. The hip and ridge shingles are not only reinforced lengthwise but also crosswise, and before the shingle is taken out of the mold it is slightly cut so that it can be bent to the desired angle, the crosswise reinforcing holding it in position. The hip shingles have the corners cut off to suit the courses of the roof shingles, thus exposing the ends of the reinforcing wires, which are bent into loops to receive the nails. All the cracks made in the hip and ridge shingles are filled with cement by the roofers. A number of roofs (old and new) have been covered with these shingles, and each roof is said to be guaranteed for 25 years by the contractor.

COST OF HYDRAULIC DREDGING, HARBOR OF WILMINGTON, CAL.

In our issue of Aug. 16, 1906, we published an extended article on the harbor improvements at San Pedro and Wilmington, Cal. On the work in question a suction dredge built by the Ellicott Machine Co., of Baltimore, Md., is employed. Prior to the acceptance of the same by the United States, and during an efficiency test, 16,450 cu. yds. of material were removed from the proposed harbor and deposited behind a bulkhead. The total cost for labor employed, including superintendence, and for the fuel, water and other supplies expended on account of this work, was $1,682.46, or at an average cost of 10²/₁₀ cts. per cu. yd. of material handled. The dredge was placed in commission April 1, 1905, and between this date and June 30, 1905, it removed 227,464 cu. yds. of material, which consisted principally of sand intermingled with shell and a small percentage of clay, cobbles, disintegrated sandstone and very compact and hard mud. During the period mentioned the dredge was laid up 16 days, May 15 to 30, 1905, so that the actual working time was 2½ months, the average rate of dredging per month being thus 91,000 cu. yds.

The following statement shows the cost of the dredging during the period from April 1 to June 30, 1905:

Routine office work, labor	$673.33
Care of plant and property, labor	180.00
Surveys, labor and supplies	155.63
Towing and dispatch work, labor, fuel & supplies	316.00
Alterations and repairs to dredging plant, labor and material	2,432.52
Operating dredge, including superintendence and labor charges, fuel, fresh water, lubricants, and all other supplies	10,084.54
Deterioration of plant and property, estimated	2,263.94
	$16,105.96

Cost per cubic yard, $0.0708.

In addition to the hydraulic dredge, the following auxiliary floating plant is employed: a gasoline launch, length over all 30 ft. 1½ ins., 7-ft. beam, depth 3 ft. 3 ins., propelled by a 16-HP. "standard" engine. Also 9 pontoons, each 35 ft. × 10 ft. × 3 ft.; 15 pontoons, each 21 ft. 3 ins. × 10 ft. × 3 ft.; 1 water boat, 34 ft. 9 ins. × 10 ft. × 4 ft. 6 ins.; 1 oil boat, 34 ft.

9 ins. × 10 ft. × 4 ft. 6 ins.; 1 derrick boat, 29 ft. 6 ins. × 10 ft. 7 ins. × 3 ft. 10 ins.

The original cost of the dredging plant was as follows:

20-in. suction dredge	$99,453
Gasoline launch	1,733
Discharge pipe line for dredge	3,023
Rubber sleeves	1,275
Pontoons and barges	6,501
Skiffs	154

COMPARATIVE TESTS OF CEMENT MORTAR, SHOWING THE RELATIVE EFFECTS OF THREE DIFFERENT SANDS.

By A. Black*, C. E.

It is frequently asked whether it is necessary, in the clause of the specifications defining the quality of the sand to be used in making concrete, to prescribe that it shall be "clean, sharp, large-grained, well-screened, free from clay, and if considered advisable, washed, etc." The value of this requirement has been frequently denied in recent years. Some go farther than this and assert that in particular cases at least, and within certain limits, unwashed sand, and the admixture up to a certain percentage of clayey material, are positive advantages. Similarly, the old idea of rejecting all screenings from stone intended for use as road metal on a macadam road was questioned, and to-day this idea is no longer held. In the making of concrete, the question of whether it is advisable to use the entire run of the crusher, with the obvious resulting advantages in economy, or whether it is better to reject by screening all particles below a certain size, is of serious practical import. There is much divergence of opinion in this matter, with able advocates ranged on either side.

I present herewith the results of comparative tests which may throw some additional light on this last problem, at any rate so far as the materials tested are concerned. The tests were planned to show the relative effects of three different sand materials on the strength of Portland cement mortar.

Material A is a crushed gneiss rock screened through a half-inch mesh.

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FINENESS, SPECIFIC GRAVITY AND PERCENTAGE OF VOIDS OF SANDS A, B AND C.

Percentage of sample coarser than corresponding sieve numbers. (See Fig. 3 for plot of results.)

Sieve number.	A	B	C
2	1.1	0.0	0.0
5	10.7	1.2	1.1
10	24.8	5.9	2.2
20	35.6	13.3	4.3
30	45.2	25.5	8.0
50	63.6	57.5	29.0
80	77.1	83.7	75.0
170	90.8	95.8	95.5

SPECIFIC GRAVITY AND PERCENTAGE OF VOIDS.

Material.	Specific Gravity. Loose.	Specific Gravity. Shaken down.	Per cent. voids. Loose.	Per cent. voids. Shaken down.	Weight per cubic foot, lbs. Loose.	Weight per cubic foot, lbs. Shaken down.
A	1.61	1.80	35.0	26.7	100.5	112.4
B	1.55	1.67	32.3	27.3	97.0	104.0
C	1.49	1.66	38.4	31.4	93.0	103.8

Material B is Cow Bay sand, much used in and about New York City for general construction purposes.

Material C is a fine and perfectly clean silicious sand.

Some of the physical characteristics of the materials used are shown in the accompanying tables, giving the fineness, specific gravity, weight per cubic foot, and precentage of voids. Fig. 3 is a diagram of the fineness results.

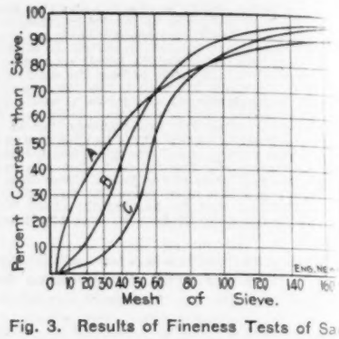

Fig. 3. Results of Fineness Tests of Sa

The results are tabulated below:

Material.	Proportions by Volume. Cement.	Sand.	Percentage of Absorption By Weight. a	b	c	By Volume. a	b	c
A	1	2	1.75	4.2	10.2	7.1	17.1	38.6
	1	3	1.70	4.6	11.0	7.1	18.6	41.4
B	1	2	1.3	3.7	8.0	5.7	15.7	32.9
	1	3	2.1	4.6	8.8	8.6	18.6	34.3
C	1	2	0.7	3.2	9.6	2.9	12.8	35.7
	1	3	1.1	4.1	10.9	4.3	15.7	38.6

It will be seen that in tests (a) and (b) the briquettes made with sand C, which gave the poorest strength results, proved to be the most dense as shown by absorption. In test (c), however, the briquettes B, which gave the best strength results, also showed lowest absorption. The crushed gneiss briquettes, A, were in all cases highest in absorption.

Since all the details of the tests were performed by the writer without any assistance, it is reasonable to assume that the inevitable personal equations affects all the results alike.

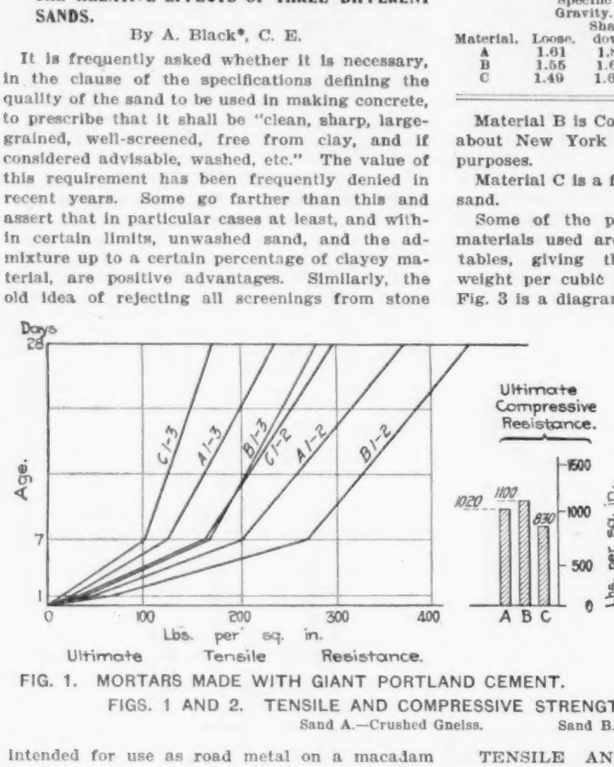

FIG. 1. MORTARS MADE WITH GIANT PORTLAND CEMENT.

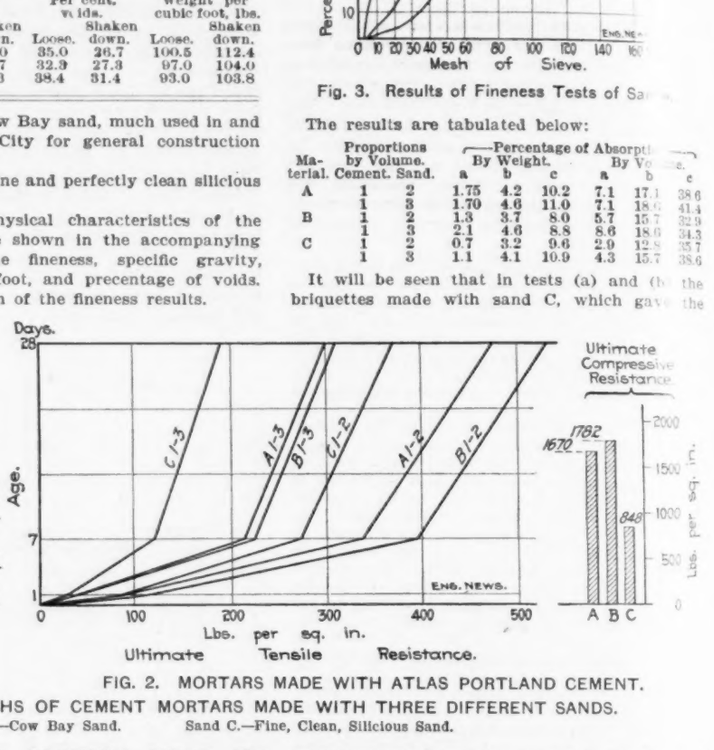

FIG. 2. MORTARS MADE WITH ATLAS PORTLAND CEMENT.

FIGS. 1 AND 2. TENSILE AND COMPRESSIVE STRENGTHS OF CEMENT MORTARS MADE WITH THREE DIFFERENT SANDS.
Sand A.—Crushed Gneiss. Sand B.—Cow Bay Sand. Sand C.—Fine, Clean, Silicious Sand.

TENSILE AND CRUSHING TESTS.—The strength tests comprised two series. In the first Giant Portland cement was used, in the second Atlas Portland cement. They are summarized in Tables I and II, and the corresponding diagrams Figs. 1 and 2. In the tensile tests each result given is the average of six or more values; in the compressive tests each result is the average of three values. The materials used were first passed through a six-mesh sieve. All proportions quoted are by volume.

ABSORPTION TESTS.—In each case two briquettes were allowed to harden for seven days in a moist box; then they were:

(a) Weighed, immersed in water for one day, and again weighed;

(b) Dried by artificial heat for one hour, weighed, immersed and weighed as above;

(c) Thoroughly dried out by artificial heat for three hours, weighed, immersed and weighed as above.

IRRIGATION EXPERIMENTS IN OKLAHOMA are being made by the U. S. Reclamation Service. A pumping plant has been erected for the purpose of determining whether or not the water of one of the rivers of the state is too salty for general use on crops. This and other studies in Oklahoma have been greatly hampered by the exceptional wetness of the present season. Thus far, examinations and surveys have not shown a project that would be economically practicable. The investigations will be continued, however.

COMPARATIVE STRENGTH TESTS OF CEMENT MORTARS MADE WITH THREE DIFFERENT SANDS.

Sand A: Crushed Gneiss.
Sand B: Cow Bay Sand.
Sand C: Fine clean silicious sand.
See table in text for mechanical analyses.

TABLE I.—Mortars of Giant Portland Cement. (See also Fig. 1.)

ULTIMATE TENSILE RESISTANCE.
In pounds per square inch.

Material	A		B		C	
Proportions	1 cement 2 sand	1 cement 3 sand	1 cement 2 sand	1 cement 3 sand	1 cement 2 sand	1 cement 3 sand
1 day	45	24	65	38	32	14
7 days	203	127	270	170	168	103
28 days	374	238	438	280	297	173

ULTIMATE COMPRESSIVE RESISTANCE OF 4-IN. CUBES.
In pounds per square inch.

Materials	A	B	C
Proportions	1 cement 3 sand	1 cement 3 sand	1 cement 3 sand
28 days	1020	1100	830

TABLE II.—Mortars of Atlas Portland Cement. (See also Fig. 2.)

ULTIMATE TENSILE RESISTANCE.
In pounds per square inch.

Material	A		B		C	
Proportions	1 cement 2 sand	1 cement 3 sand	1 cement 2 sand	1 cement 3 sand	1 cement 2 sand	1 cement 3 sand
1 day	87	37	106	39	86	29
7 days	337	214	397	224	273	192
28 days	476	301	530	311	371	241
6 weeks	....	....	....	....	419	312
10 weeks	....	....	564	392	....	....

ULTIMATE COMPRESSIVE RESISTANCE OF 4-IN. CUBES.
In pounds per square inch.

Material	A	B	C
Proportions	1 cement 3 sand	1 cement 3 sand	1 cement 3 sand
28 days	1670	1789	84

NOTE.—All proportions are by volume.

INSTRUCTIONS TO INSPECTORS ON REINFORCED CONCRETE ARCH CONSTRUCTION.

The following comprehensive instructions to reinforced concrete arch inspectors will be of interest and possible direct value to many engineers engaged in reinforced concrete construction. They were submitted to this journal by Mr. Geo. P. Carver, Division Engineer, Florida East Coast Railway, Miami, Fla. This railway, as is widely known, has a great length of reinforced concrete arch viaduct. The instructions are as follows:

Inspectors will be required to become familiar with and carefully follow out the following instructions regarding inspection and see that the work is carried out in strict accordance with same. An inspector will be required to be on the work during the setting of forms, placing of reinforcement and the mixing and placing of concrete. He will represent the Engineer-in-Charge, and will be held responsible for the correct performance of the work assigned to him. He will, in a general way, carefully and continuously watch the progress of the work, making a record of the amount of work done each day and the manner in which it is done.

He will be required to become thoroughly familiar with the plans of the work which he is inspecting, that he may intelligently perform the duties intrusted to him. He will be required to fill in a daily report sheet, printed forms being furnished for this purpose, giving the location of the work, the amount of work done, the number of batches mixed and placed, the proportions used, the arrival of material and all such other information as will assist in making a concise and accurate record of the progress and cost of the whole or any part of the work. He will see that the following specific instructions are carried out:

FORMS.

That the forms are properly set up and braced.

That the concrete face of the forms are given a coat of oil, applied with a brush.

That an excess of oil is not used.

That the forms are cleaned at each setting and recoated with oil.

That the forms are correctly placed, allowing the depth, width and batter called for on the plans.

That the inside of the forms is free from debris (shavings, sawdust, blocks of wood, etc.) just previous to pouring.

That the forms are properly held together with No. 9 wire or rods of suitable dimensions, and temporary spacing pieces are used and removed when the concrete reaches their height.

That the joints formed by the edges of the lagging are tight, so that grout will not escape, and that such defects are remedied by the use of plaster of paris, calking, strips of wood or other suitable approved method.

That the arch centers are lowered sufficiently to allow the arch ring to assume its permanent set before spandrel walls are poured, in this manner reducing the possibilities of cracks occurring in spandrel walls because of possible excessive settlement in crown of arch ring.

STEEL REINFORCEMENT.

That the correct number and size of reinforcing bars are used, and that they are placed as shown on plan.

That all steel used is free from loose or scaly rust. (A thin film of rust will not cause the rejection of a bar.)

That bars covered with loose, scaly rust are cleaned with a stiff wire brush or given a pickling bath of a sulphuric acid solution (consisting of 1 part acid to 6 parts of water) and dipped in clean water.

That the intersection of the rods are wound with a length of No. 18 wire in a sufficient number of places so that the whole steel reinforcement will be fabricated sufficiently strong and rigid to withstand the placing of concrete about the steel and without disturbing the position of same.

That the bars are spaced the proper distance apart and away from the face of the form work and are secured properly and held in that position in such a manner that they will not be disturbed by the placing of concrete.

That all protruding bars from piers and arches to which other bars are to be spliced and which will be exposed to the action of the weather for an indefinite period are protected from rusting by a coat of thin, neat cement grout.

That the position of the steel is not disturbed during pouring.

PLACING CONCRETE.

The inspector will see that the specified proportions of materials are used in mixing the concrete.

That the concrete is of the proper consistency.

That an accurate account is kept of the number of batches mixed, the same to be recorded on a printed card which will be furnished for that purpose.

That these batch record cards are preserved and filed for future reference.

That in placing the concrete the same will be done in a careful manner and precautions taken not to allow the concrete bucket to come in contact with the form work.

That care is taken not to jar the form work until the concrete work is hardened.

That in making a bond between old and new work care is taken to thoroughly clean the surface of old concrete (preferably by a jet of steam), and that a thin layer of a 1 to 1 grout is spread to assist in making a good bond.

That the surface of the concrete which is to be bonded to other concrete is left in a rough condition, either by spreading a layer of broken stone over the same, running half the depth of the stone into the green concrete and leaving the upper half of the stone protruding, or by setting in strips of wood, which, when removed, will form a groove and assist in making a good bond.

That in bonding the spandrel wall with the arch ring, a groove or ridge is formed on arch rings running under and with spandrel wall to prevent water from center filling to run through and down the face of arch ring, discoloring same.

That in placing dry concrete the same is thoroughly compacted with suitable approved iron tamps.

That in pouring wet concrete the same is thoroughly spaded, rodded and worked with suitable tools sufficiently to cause all air bubbles to escape, to work grout to face of form work filling all voids and showing a smooth, well-mixed concrete free from voids when forms are removed.

That a fine mixture of 1 to 3 is deposited around and among the bars, and that it is thoroughly worked in and around the bars in such a manner that the steel will be completely surrounded, embedded and covered.

That all concrete is deposited in forms within 30 minutes after leaving mixer.

That all exposed surfaces of concrete are kept continually wet for a period of ten days after removal of forms.

IN GENERAL.

A record book will be furnished the inspector, in which a record will be kept of the progress of the work, and the following information should be recorded: Date; time of day of each entry; day or night work; number of men; foreman; condition of forms; condition of steel; number and location of lights (if night work) and if properly lighted; number, time and location of test cubes taken; rate of mixing; size and number of batches; proportions of mixture; name or number of work barge; arrival of material; kind and amount and on what barge.

Inspectors will be required to fill in several daily report blanks that will be furnished.

Inspectors will receive further written instructions from the Engineer-in-Charge from time to time, and will attach same to these instructions and will consider them a part of same.

Care should be taken not to allow the first concrete placed to appreciably stiffen or set before the remaining concrete is placed. The remedy for this is to occasionally, as often as is necessary, add a little more concrete to that already placed over all exposed surfaces.

Great attention is necessary to make each section (pier, arch ring or spandrel wall) monolithic in height, length and width. Only when circumstances render it practically unavoidable may the work be stopped before the entire section is completed.

Order and close attention to details is essential. Carelessness in proportioning, in mixing or compacting the materials, or the omission or misplacement of the steel bars, may cause defective or even destructive results. Reinforced concrete construction requires close, continuous and intelligent supervision.

RIVERS POLLUTION PREVENTION AND SEWAGE TREATMENT IN THE MERSEY AND IRWELL DRAINAGE AREAS, ENGLAND.

The extent to which sewage treatment is carried in some parts of England is very well illustrated by the report of Mr. R. A. Tatton, M. Inst. C. E., Chief Inspector to the Mersey and Irwell Joint Committee. The report is dated May, 1906, and covers the years 1905-06. The committee has jurisdiction over the Rivers Irwell, Roach, Irk, Medlock and Mersey. In this district there is a population of about 2,550,000. There are 419 manufacturing plants under the jurisdiction of the committee. Of the latter, 294 have sewage treatment works classed as "efficient" and 117 as "inefficient," while 3 works are under construction—leaving only 5 where the manufacturing wastes are not treated in some manner before their final discharge. Of the inefficient works, many have too limited surroundings to permit of the establishment of efficient purification works. In addition to the 419 manufactories, there are, of course, many which are connected with local sewers.

Considerable attention is being given to the recovery of waste products at the manufacturing plants. This, Mr. Tatton states, will be of great benefit, both to the manufacturers and to the river.

Mr. Tatton remarks that "a stream which has once been seriously polluted seems to be peculiarly sensitive to impure effluents," and is liable to give rise to nuisance in hot weather. He also speaks of the attention being given to rivers pollution in other countries. On the River Emscher, a tributary of the Rhine, a commission has been created, with "power to construct the works required for the treatment of the sewage and trade waste, and to levy rates for the cost of construction and upkeep."

Of the 21 boroughs in the area under the jurisdiction of the committee (population 1,817,897), all have had sewage works in operation for two years past.

Some very interesting general remarks on the subject of sewage treatment, and also some statements regarding recent increase of various filtration areas, may be quoted as follows:

Further experience confirms the views which the committee have advocated—that methods of treating sewage by artificial means where the land is unsuitable may, if properly constructed and used, be relied upon to give good results. The watershed affords instances of many types of such methods; septic tanks, sedimentation tanks—with and without a precipitant—contact beds—single and double—percolating filters, made with both coarse and fine material and of varying depths. Good results are obtained with all these methods, and the question which one should be adopted in any particular case depends entirely on local circumstances. In addition to the prime cost, the upkeep of the filters or beds is an important item in the future annual cost of the works. The more thoroughly the solid matter is removed from the sewage before it goes on to the beds the longer the beds will last without renewal, and in designing works, therefore, the question of dealing with the solid matter becomes of the greatest importance. If suitable filtering material can be obtained cheaply, and beds constructed economically, more work may be thrown upon them, but if they are expensive to construct the burden of extracting the solid matter must be thrown as much as possible upon the tanks. It is generally admitted now that the percentage of solid matter destroyed by bacterial action is only small, and that the bulk of it is retained either in the tanks or in the filters.

The last two years have shown a considerable increase in filtration areas: At Manchester the area has been increased from 52 acres to 73 acres, at Salford from 5½ to 7½ acres; the total area for the seven county boroughs amounts to 109 acres at the present time, against 76 acres two years ago. Further extensions are being carried out or are shortly to be taken in hand at Manchester, Salford, Bolton and Oldham.

Amongst the smaller authorities also considerable progress in the same direction has been made.

The tendency to attempt to work sewage farms at a profit is still an obstacle in the way of successful treatment on land, and although many farms on the watershed are worked very satisfactorily, and with a view primarily to the treatment of the sewage, others are not given a chance owing to what should certainly be called bad management. When we find potatoes, wheat, carrots, etc., being grown, as is the case on the Bolton farm at Rhodes, we know that the treatment of the sewage is not the first consideration, as such crops are quite unsuitable for the application of sewage during the summer months.

Storm water, as has been pointed out in previous reports, still causes serious pollution, the chief damage being done during sudden thunderstorms in summer, when the rivers are low and incapable of carrying forward the solid matter which the storm water contains. If the outfall works are not capable of dealing with the increased volume by filtration, spare tanks should be kept, through which the storm water can be passed in order, at any rate, to remove the solid matter in suspension; this materially reduces the harm which is done to the streams.

Particular attention may well be called to Mr. Tatton's statement to the effect that good results are obtained from a considerable number and variety of methods of sewage treatment. Not all British writers, we regret to say, are so judicial in their utterances.

CALCIUM HYDRIDE, PRODUCING HYDROGEN in the same way that calcium carbide produces acetylene, was described recently by Mr. Geo. P. Jaubert before the French Academy of Sciences. The new material when brought into contact with water generates hydrogen, at the rate of 18.5 cu. ft. per pound of chemically pure material, or 16.1 cu. ft. per pound of commercial hydride. The material is considered to be of great importance for ballooning. The name hydrolith has been suggested for it.

THE GORTON SYSTEM OF STEAM HEATING.

The Gorton vapor vacuum system of heating is simply an ordinary two-pipe dry return steam system fitted with patent automatic drainage and relief valves. The drainage valves are placed at the return end of each radiator, while the relief valve is connected to the steam and return mains, as shown in Fig. 1. A relief pipe branches from the top of the return mains and connects with the relief valve. Likewise a steam pipe is run from the top of the steam main to the under side of the relief valve. The relief valve is adjusted by sliding a weight (Fig. 2) out on a lever until steam flows freely from the exhaust and the return mains become heated. The weight is then pushed back until the flow of steam is checked, when it is fastened to the lever by a set screw, after which the valve needs no further attention, being entirely automatic in action, irrespective of the pressure of steam in the boiler.

The manner in which the system operates is very simple. As the live steam is admitted to the radiators it forces the air and condensed steam through the drainage valves into the return mains. Upon reaching the boiler the water and air become separated, the water flowing into the boiler, while the air rises in the relief pipe and flows to the relief valve, which operates, allowing the air to escape from the system, when the air pressure about equals that of the steam. In other words, the valve is a differential pressure valve, the air pressure being applied to one side of a rubber disk (Fig. 2) and steam to the other side.

The principal advantage claimed for this system is that the heat of each room can be controlled, independent of all others, by adjusting the amount of steam admitted to the radiators. This is made possible by the use of the drainage and relief valves which always keep the radiators free of air and condensed steam, irrespective of the amount of steam admitted to the radiator, steam pressure and outside temperature. Thus, if the steam valve is opened half way, only half as much steam will be admitted to the radiator as when the valve is wide open, and therefore only one-half as many heat units will be given off as the steam is condensed by the radiator. In other words, only half of the radiator will be heated. Furthermore, no air valves are used on the radiators, thus doing away with one of the annoying features found in all other steam systems. Another advantage is that any steam fitter can install the system, since there is no difference between it and the ordinary two pipe system, except that the special relief and drainage valves are required. The system is controlled by the Gorton & Lidgerwood Co., 96 Liberty St., New York City.

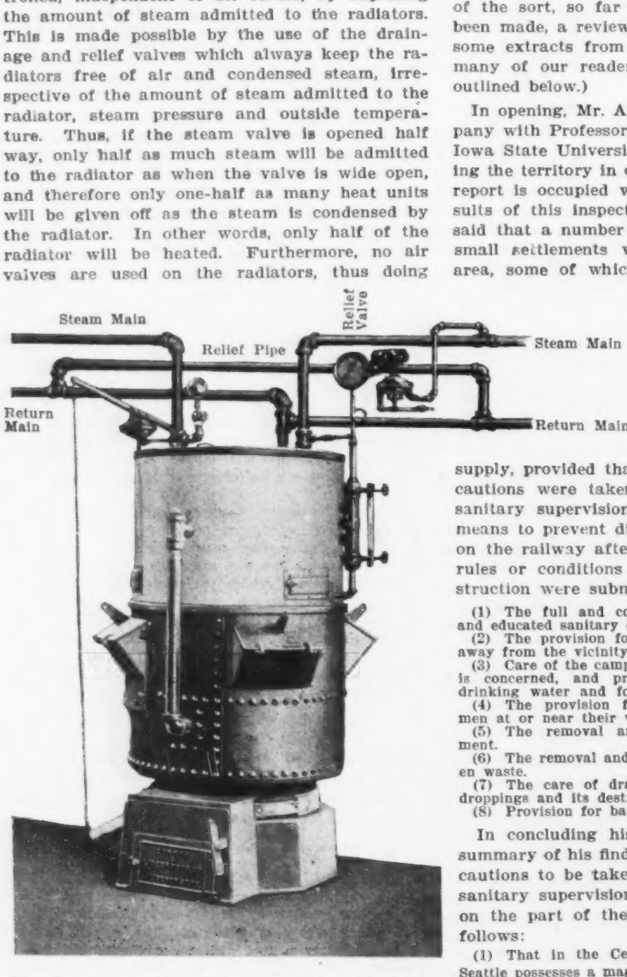

Fig. 1. Gorton Vapor Vacuum System: Arrangement of Piping at Boiler with Relief Valve Connected to the Mains.

REPORT ON POSSIBLE POLLUTION OF THE WATER SUPPLY OF SEATTLE BY A PROPOSED RAILWAY THROUGHOUT THE DRAINAGE AREA.

Novel questions pertaining to the water supply of Seattle have arisen in connection with the proposed construction of a railway through the city's Cedar River drainage area by the Chicago, Milwaukee & St. Paul Ry. Co. The Pacific Coast extension of this railway, as planned, would run through the drainage area for eleven miles, mostly along or quite near the river, above the intake. The King County Medical Society voiced a fear that the construction and operation of the railway would result in dangerous pollution to the water supply. Popular agitation and much opposition following, the railway company engaged Mr. John W. Alvord, M. Am. Soc. C. E., of Chicago, Profs. Wm. T. Sedgwick, of Boston, Erastus G. Smith, of Beloit, Wis., and Louis H. Pammel and Geo. H. Bissell, of Ames, Ia., to investigate and report on the subject. Profs. Sedgwick and Smith being delayed in reaching Seattle, and the railway company apparently being anxious to give the public information as soon as possible, Mr. Alvord's report was published first, appearing in full in the Seattle "Times" of July 26, 1906. As this is the first investigation of the sort, so far as we know, that has ever been made, a review of the report, together with some extracts from it, would doubtless interest many of our readers. (Subsequent reports are outlined below.)

In opening, Mr. Alvord states that he, in company with Professors Bissell and Pammel, of the Iowa State University, spent a week in examining the territory in question. A large part of the report is occupied with a description of the results of this inspection. In general, it may be said that a number of logging camps and other small settlements were found in the drainage area, some of which were contributing directly and others indirectly to the pollution of the water supply.

Mr. Alvord was of the opinion that a railway might be constructed and operated through the drainage area without any menace to the water supply, provided that certain easily effected precautions were taken. These would include the sanitary supervision of construction camps and means to prevent direct pollution of the streams on the railway after it was in operation. Eight rules or conditions to be observed during construction were submitted, as follows:

(1) The full and complete authority of a competent and educated sanitary officer, with suitable assistance.
(2) The provision for proper location of camps safely away from the vicinity of the river.
(3) Care of the camps, so far as the health of the men is concerned, and provision for the purity of their drinking water and food supplies.
(4) The provision for suitable conveniences for the men at or near their work.
(5) The removal and destruction of human excrement.
(6) The removal and destruction of garbage and kitchen waste.
(7) The care of draught animals, collection of their droppings and its destruction.
(8) Provision for bathing purposes.

In concluding his report, Mr. Alvord gave a summary of his findings, both as regards the precautions to be taken by the railway and needed sanitary supervision of the whole drainage area on the part of the city. These findings are as follows:

(1) That in the Cedar River watershed the City of Seattle possesses a magnificent source of water supply.

(2) That the city is not now and has not in the last few years properly protected this area from gross pollutions now existent.

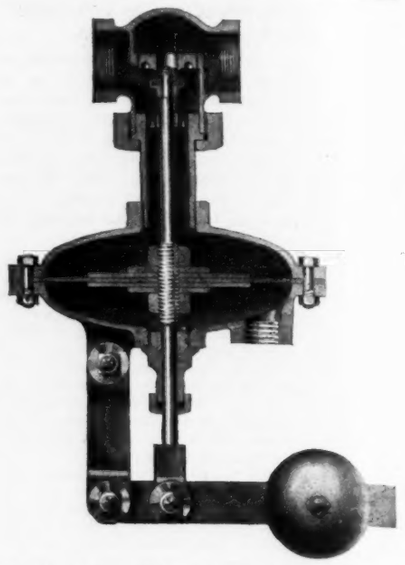

Fig .2. Cross-Section of the Automotic Relief Valve, Gorton Vapor Vacuum System.

(3) That a virgin forest or inaccessible country does not afford ideal protection from pollution, but, on the contrary, a district easily accessible in every part and open to the publicity of frequent inspections and control offers the greatest degree of protection.

(4) It is the settled policy, therefore, of most sanitary control of watersheds, while preventing as far as possible the growth of population and the incidental pollution therefrom, to open watersheds freely to the public observation, by creating means of access which facilitate inspection.

(5) Railroads, so far as the track and trains are concerned, when properly regulated, are not regarded as a menace to the purity of the surface waters by sanitary authorities.

(6) It is through population and industries created by railroads that sanitary difficulties occur.

(7) The twenty-five miles or so of railway now existing in the Cedar River watershed are in themselves no menace to the valley, but the logging camps which they serve are so conducted as to be serious pollutions in many cases.

(8) That the operation of a completed railway line by the Chicago, Milwaukee & St. Paul Ry. Co. on or near the present location can be made entirely safe by some simple precautions, such as fencing, drainage, closed bridge floors and locked water closets.

(9) That care should be exercised during the period of construction of the railroad to prevent all access to the water by men or animals. For this purpose the river front should be entirely fenced off, policed, and where necessary, water should be pumped up to the camps from the river under pressure, and in suitable quantities, for all purposes, including bathing and watering animals.

(10) That efficient sanitary control should be had over all camps, cleanliness enforced, refuse of all kinds promptly collected and burned, drainage filtered and commodious and convenient sanitary arrangements provided and strict control and authority maintained.

(11) That the City of Seattle should also fence in the road which it has constructed along the river bank between Barneston and the power house, so as to prevent access therefrom to the river.

(12) That the City of Seattle should regulate and control by intelligent sanitary rules the various logging camps now existing upon the watershed.

(13) That it would be highly desirable to prevent decaying wood and vegetable matter from defacing the shores of Cedar River and its important tributaries, and cut off the swamps at the outlet of Cedar Lake and immediately above the intake.

In connection with his study of the problem, Mr. Alvord collected and tabulated information regarding railways which pass through existing water-works drainage areas in various parts of the country. This table is reprinted herewith.

Since the foregoing notes on Mr. Alvord's report were put in type, we have received information on certain later developments at Seattle, which we outline briefly below:

After no little local agitation, it was decided by all parties interested to leave the final decision as to the passage of the railway through the Seattle water-works drainage area to Prof. A.

C. Abbott, of Philadelphia, as representing the city; Prof. Charles Harrington, of Boston, for the King County Medical Society, and Prof. William T. Sedgwick, of Boston, for the railway company. About this time, Mr. John R. Freeman, M. Am. Soc. C. E., arrived in Seattle on his way to Alaska, and was engaged to represent the Washington State Board of Health in the investigation. A three days' trip through the drainage area was thereupon taken by Messrs. Freeman, Harrington and Sedgwick (Dr. Abbott arriving and making the trip later), accompanied also by Dr. E. C. Heg, Secretary of the Washington State Board of Health, Prof. William J. Roberts, Engineer to the Board (professor of civil engineering at Washington Agricultural College, Pullman, Wash.), Mr. R. H. Thomson, M. Am. Soc. C. E., City Engineer of Seattle, and Prof. E. G. Smith, of Beloit, Wis. A preliminary report was made by Mr. Freeman and was in the hands of the commission of three named above.

The substance of the report by Messrs. Abbott, Harrington and Sedgwick may be briefly given as follows: First of all, the commission stated that it had no "hesitation" in saying that the railroad might be constructed along Cedar River "without danger to the character and wholesomeness of the water supply of Seattle," and also that if constructed it would be possible to operate the road "without endangering the public health of said city, through pollution of the stream." The general absence of gravel and sand in the vicinity of the proposed railway location would make necessary special provision for the safe disposal of waste matters during the construction and operation of the road, since otherwise these wastes would, if deposited on the surface of the ground, be washed into the river by heavy rains. Two of the necessary railway construction camps could be located outside the drainage area, and the two others could be established some 500 ft. or more away from the river, on benches of gravelly, dry and porous soil. The necessary camp latrines could consist of

reasonably deep pits for the reception of the discharges, which, out of abundant caution, should be disinfected by the application of milk of lime, made from freshly slaked lime and kept protected from contact with the air. This should be prepared as often as twice per week, since with age it loses in causticity and germicidal power. As the pits become nearly filled, the filling should be completed with clean soil, and new ones should be dug.

It is suggested that other latrines should be established between camps, at intervals of a few hundred feet, and that in addition portable privies should be used and that the latter should be frequently cleaned and disinfected. Bathing and laundry work in the river should be absolutely prohibited.

For the protection of the water supply after the railway is put in operation, it is suggested in the report that work trains should be provided with portable privies consisting of water-tight boxes or tanks; also that the water closets of all passenger trains should be locked while they are passing through the drainage area. Bridges should be provided with steel decks, ballasted with gravel and sand, and provided with drainage facilities discharging at least 50 ft. from the river bank onto "appropriate areas or into gravel beds." The location of stations or roundhouses within the drainage areas should be prohibited, not only by the proposed city ordinance giving the railway company the right-of-way, but also in the city's deed of land for right-of-way.

During construction a sanitary police system should be established, under the control of a sanitary engineer appointed by the city and approved by the State Board of Health. Medical inspectors should also be provided. After the railway is put in operation, a competent sanitary inspector should continue to have jurisdiction of the right-of-way.

In conclusion, the commission lays stress on the importance of protecting the water supply from dangers from chance pollution throughout the drainage area, which dangers, it states, are "of far greater importance than any likely to be caused by the operation of a properly constructed and efficiently guarded railway." These dangers arise from camps, fishermen, etc., within the drainage area, and are all the greater because the water is subjected to neither storage nor filtration. A previous recommendation of the city engineer, for a large impounding reservoir between Cedar Lake and the power-house, is endorsed by the commission.

STUDIES OF FLUCTUATIONS IN THE WATER LEVEL OF LONG ISLAND WELLS.

The wells of Long Island, N. Y., have for many years been an interesting subject for speculation, and later for scientific study. The results of some of these studies were included in the report of the New York Commission on Additional Water Supply, published several years ago. Detailed results of studies made by the U. S. Geological Survey, partly at least in connection with the work of the commission just named, are presented in Water Supply and Irrigation Paper No. 155 of the Survey. The paper was written by Mr. A. C. Veatch, who prefaces it with an interesting summary, which we quote as follows:

(1) The most important and characteristic of the natural ground-water fluctuations is the regular annual period. This is a relatively uniform curve, with a single maximum and minimum, on which the fluctuations of shorter periods, as a rule, form but minor irregularities. This curve does not generally resemble the rainfall curve. Were the rainfall uniform throughout the year, the ground-water would still show a regular yearly period and the maximum would occur early in the year in the North Temperate Zone. The effect of irregularities in the rainfall is to move the time of occurrence of this maximum either forward or back.

(2) The water from single showers is generally delivered gradually to the ground-water table, and even where noticeable fluctuations are produced, these do not commonly make important irregularities in the regular annual ground-water curve.

(3) Single showers may, by transmitted pressure through the soil air, produce instantaneous and noticeable rises in the water in wells and notably increase the stream discharge without contributing either to the ground-water or directly to the surface flow.

(4) The amount contributed to the ground-water cannot be satisfactorily estimated by the rise and fall of the water in wells, because the same amount of rainfall under the same geologic and climatic conditions, in beds of the same porosity, will produce fluctuations of very different values. Near the ground-water outlet the total yearly range may be but a few inches, while near the ground-water divide it may be 50 or 100 ft. When an attempt is made to calculate the amount of water received from single rains, the results are not reliable, because in the cases which are usually taken, such as sharp, quick rises, it is impossible to tell how much of the rise is due to transmitted pressure and how much to direct infiltration.

(5) Because of the increase in stream flow due (1) to transmitted pressure from rains, (2) to changes in barometric pressure, and (3) to increase in area of ground-water discharge, with the elevation of the ground-water table, it is not possible to correctly separate the quantity of water in the stream discharge contributed by spring flow from that contributed by direct surface run-off. There are many reasons for believing that in humid regions "flood flows" contain large percentages of ground water.

(6) Tidal fluctuations in wells are very often produced by a plastic deformation due to the loading of the tides, and the occurrence of such fluctuations in wells does not in itself indicate a connection between the water-bearing strata and the sea.

(7) Temperature changes may produce marked fluctuations (1) by changes in capillary attraction—such fluctuations are perceptible only at the surface of the zone of complete saturation, are not transmitted to deeper levels, and vary directly with the temperature; (2) by changes in viscosity or rate of flow—fluctuations due to this cause vary inversely with the temperature, and show in deep wells by transmitted pressure.

NOTES FROM ENGINEERING SCHOOLS.

INTERNATIONAL CORRESPONDENCE SCHOOLS.—The fifteenth anniversary of the Schools will be held Oct. 16, at Scranton, Pa. The day will be taken up with addresses, etc. The buildings will be thrown open for inspection and a chance given visitors to see the manner in which the work of the Schools is carried on.

THE SINGER BUILDING EXTENSION, New York City, which will have a tower 42 stories or 625 ft. high, is to be put under construction at once, the foundation contract having been let to The Foundation Co., 35 Nassau St., New York City. The foundations will include 30 pneumatic caissons, carried to bed rock, which is at an average depth of about 80 ft. below the curb line. The extension will be located on the west side of Broadway, near Liberty St.

THE CROTON FALLS DAM CONTRACT has been awarded by the Croton Aqueduct Commission, New York City, to James Malloy & Co., North 15th St., Brooklyn, N. Y. The company's bid was $3,028,853. A brief note on this dam was published on page 179 of our issue of Aug. 16, and the detailed contract prices were given on page 68 of our Construction News Supplement of Aug. 23.

THE WATER SUPPLY OF ROGERS PARK, a residence section of Chicago, has been attracting a great deal of attention in the Chicago press. Some particulars relating to this subject were given on page 179 of our issue of Aug. 16. From a report submitted to the mayor by the health department, it appears that the supply is taken from Lake Michigan, at a point 3,300 ft. from the shore where the water has a depth of 20 ft. It is stated that winds of moderate velocity give rise to turbidity, excessive sediment and organic matter in the water at the intake. It also appears from the report that the water delivered to consumers is unsatisfactory, notwithstanding the fact that the water is subjected to sedimentation, coagulation and filtration. The report states that the amount of alum used varies from 1/8 to 2 grains per gal., but that "less than 1 grain is valueless as a precipitant in water so heavily charged with organic matter." Besides the inadequate amount of alum used at times, the report states that, although the daily consumption ranges from 1,500,000 gals. in winter to 2,000,000 gals. in summer, the filters have a nominal maximum capacity of 500,000 gals. per day, only. It is stated that the filters are satisfactory up to the limits of their capacity. It is recommended that the intake should be extended to 30 ft. of water; that the city should connect with the intercepting sewer system certain sewers now emptying directly into the lake; that the use of the stand-pipe should be discontinued; and that the capacity of the filter plant should be quadrupled. The objection to the stand-pipe is stated as follows:

When an unusual demand is made on the supply—as in case of a fire—water is pumped through this pipe direct from the bottom of the lake, without sedimentation or filtration. The interior of the pipe, as well as of the mains themselves, thus become polluted, and it may take weeks of the passage of filtered water before the pipe and mains are again cleansed. The stand-pipe should be abolished and the filtered water be pumped direct into the distributing mains, as is done in the eight city stations.

THE COLORADO RIVER continues to discharge into the Salton Sea instead of the Gulf of California. According to Mr. C. E. Grunsky, M. Am. Soc. C. E., Consulting Engineer of the U. S. Reclamation Service, who has recently made an extensive trip through the West,

RAILWAYS IN WATER-WORKS DRAINAGE AREAS.

City.	Population in 1900.	Source.	Approximate Mileage of Railroads and Number of Stations.
New York	3,350,000	Croton River	45 miles R. R., 18 stations.
Boston	560,000	Nashua River, Sudbury and Cochituate	34 miles.
Baltimore	508,000	Gunpowder River	38 miles parallel, 41 stations on map.
San Francisco	342,000	Lake Merced, Mountain streams	None.
Providence, R. I.	175,000	Pawtuxet River	10 miles, 10 stations.
Kansas City	163,700	Missouri River	Over 300 miles in immediate vicinity.
St. Paul	163,000	Small lakes	No railroad.
Rochester, N. Y.	162,000	Hemlock Lake	No railroad. Summer resort around lake.
Denver, Colo.	133,850	South Platte	75 miles, 14 stations.
Worcester, Mass.	118,400	Lynde Brook	No railroad.
New Haven	108,000	Mill River	35 miles, 10 stations.
Fall River	104,800	Watuppa Lake	5 miles, 3 stations.
Omaha, Nebr.	140,000	Missouri River	210 miles below Sioux City, 12 stations.
Scranton, Pa.	102,000	Roaring Brook, Oak River	10 miles.
Cambridge, Mass.	92,000	Stony Brook	5 miles.
Grand Rapids	87,500	Grand River	260 miles, 70 stations.
Richmond	85,000	James River	150 miles parallel, 92 stations.
Hartford, Conn.	80,000	(Brooks)	15 miles, 4 stations.
Trenton, N. J.	75,000	Delaware River	100 miles parallel.
Waterbury	45,800	(Ponds)	No railroad.
Mobile	38,400	Clear Creek	No railroad.

the river discharge in the direction named recently amounted to 20,000 sec.-ft. per day. Mr. Grunsky states that the Southern Pacific Railroad Co. is continuing the work begun by the canal company some time ago, to turn the river back into the gulf. Detailed information regarding the diversion of the Colorado River was given in our issues of Feb. 22, March 15 and May 10, 1906.

RAILWAY ACCIDENTS IN THE UNITED STATES for the three months of 1906, according to Accident Bulletin No. 19 of the Interstate Commerce Commission, resulted in 274 deaths and 3,969 injuries. Accidents to employees while engaged in their work, to passengers while getting on or off trains, etc., raise the total number of killed to 1,126 and the injured to 17,170. The bulletin characterizes the casualties for the quarter as "large," and adds:

The only sure conclusion that can be reached from these statistical comparisons, in whatever aspect they are taken, is that the Government should investigate the disastrous collisions, derailments, and other accidents on which they are based, and set forth in unmistakable terms their causes and remedies.

In addition to the foregoing, the following quotation regarding the worst accident of the quarter may be made:

The worst accident in the present quarter's record, causing 34 deaths and 24 injuries, was due to a striking failure of the train-dispatching system. A telegraph operator at a small and lonely station who had been on duty all day and more than half the night fell asleep, and, on awakening, misinformed the train dispatcher as to what had occurred while he had slept. On some railroads the train-dispatching rules require that the telegraph operator's train-order signal shall always be set to indicate "stop" except when, on the approach of a train, the operator, by pulling a lever or a cord, changes it to the "proceed" position. This rule is designed to insure that no train shall pass a station except when the operator at that station is awake and attentive to duty. This rule was not in force at this place. It is sometimes advocated that the superior train—the one which by the order is to have its right to the track abridged—must receive the order and acknowledge its receipt in writing before the order is delivered to the opposing or inferior train. Neither of these ideas finds universal acceptance, however; and, in view of the differences of opinion among railroad officers on the points involved, and on other details of train dispatching, it is pertinent to observe that the block system, repeatedly advocated by the Commission, is the true means that ought to be adopted for the prevention of such distressing disasters as that here recorded.

TOPOGRAPHIC SURVEYS are now being conducted in a number of the Central States, by the U. S. Geological Survey. In Illinois, parties are at work in ten counties. The surveys there are being made in conjunction with the Illinois State Geological Survey, of which Mr. H. Foster Bain, of Urbana, Ill., is director. The State of Illinois appropriated $10,000 a year for the years 1905 and 1906, with the understanding that the national government would spend an equal sum. Surveys are also in progress in Iowa, Kansas, Minnesota, North Dakota and Missouri. In Kansas, a party has begun work for a topographic map of an area of about 400 sq. miles in the neighborhood of Fort Leavenworth. This survey is being made at the request of the War Department, and it is expected that the results will be of use in connection with studies and maneuvers carried on at the fort.

THE UNITED STATES NAVY now has a number of warships under construction, as follows: Twelve battleships, 6 armored cruisers, 2 protected cruisers, 3 scout cruisers, 4 submarine torpedo boats and 2 training ships. The following list of these vessels shows the percentage of work done up to Aug. 1; the "Virginia" was completed during July:

Battleships.	Speed, knots.	Builder.	Percentage of work done.
Virginia.....	19	Newport News Shipbldg. Co.	(Completed.)
Nebraska.....	19	Moran Bros. Co.....	96.00
Georgia.....	19	Bath Iron Works.....	98.43
Connecticut....	18	Navy Yard, New York.....	97.00
Vermont.....	18	Fore River Shipbldg. Co....	90.50
Kansas.....	18	New York Shipbldg. Co.....	85.80
Minnesota.....	18	Newport News Shipbldg. Co.	93.68
Mississippi.....	17	Wm. Cramp & Sons.....	60.83
Idaho.....	17	Wm. Cramp & Sons.....	59.00
New Hampshire	18	New York Shipbldg. Co.....	50.30
South Carolina.	..	Wm. Cramp & Sons.....	0.
Michigan.....	..	New York Shipbldg. Co.....	0.
Armored Cruisers:			
California.....	..	Union Iron Works.....	94.6
South Dakota...	..	Union Iron Works.....	92.4
Tennessee.....	..	Wm. Cramp & Sons.....	100.
Washington....	..	New York Shipbldg. Co.....	100.
North Carolina.	..	Newport News Shipbldg. Co.	53.87
Montana.....	..	Newport News Shipbldg. Co.	47.66
Protected Cruisers:			
St. Louis.....	22	Neafie & Levy S. & E. B. Co..	99.22
Milwaukee.....	22	Union Iron Works.....	97.9
Scout Cruisers:			
Chester.....	..	Bath Iron Works.....	40.80
Birmingham...	..	Fore River Shipbldg. Co....	41.80
Salem.....	..	Fore River Shipbldg. Co....	42.6
Submarine Torpedo Boats:			
No. 9.....	..	Fore River Shipbldg. Co....	81.7
No. 10.....	..	" " " "	69.3
No. 11.....	..	" " " "	81.3
No. 12.....	..	" " " "	65.1
Training Ships:			
Cumberland....(Sails.)		Navy Yard, Boston.....	95.0
Intrepid..... (Sails.)		Navy Yard, San Francisco.	97.5

THE LAKE-AND-GULF DEEP WATERWAY project is being exploited in the present Illinois political campaign, and its advocates talk about its use as route for ocean steamers. The Chicago Drainage Canal has cost about $50,000,000, and extends to about 40 miles from Lake Michigan; a 14-ft. channel extension to the Mississippi at St. Louis is estimated by the government engineers to cost about $30,000,000, but would of course be useless for any but small steamers. How a deep channel is to be permanently maintained through several hundreds of miles of such a river as the Mississippi has not yet been explained. As to the cost, however, one advocate has estimated it at the convenient round sum of $80,000,000 for the construction of a deep channel from the Chicago Drainage Canal to the Gulf. Even supposing the waterway could be established for any such sum it would be of little use for commerce and would have little if any effect upon railway rates, as has been frequently demonstrated, although one great popular argument made for it is that it would bring about great reductions in these rates. And meanwhile, work is slowly and tediously progressing on the little 7-ft. Hennepin Canal which its advocates fondly expect to bring about radical changes in railway rates by enabling barges to pass from the Mississippi River to Lake Michigan.

THE PRICE OF PLATINUM has advanced rapidly of late on account of the recent disturbances in Russia. A rise of 15% in a single week is reported, and of 50% in the past year. The present price is three times that of 15 years ago. In the last fiscal year the United States imported 9,269 lbs. of platinum, valued by the government at $2,678,546; this is nearly one-half of the entire production of the metal.

ADVANCES IN THE PRICE OF LABOR AND MATERIALS are seriously delaying some of the irrigation projects now being carried out by the U. S. Reclamation Service. A number of contractors have failed, necessitating the carrying on of the work by the government direct, at considerable increase in cost.

EXPERIMENTS ON ERRORS OF OBSERVATION were undertaken by Prof. Mansfield Merriman, of Lehigh University, as reported by him before Section D of the American Association for the Advancement of Science at Ithaca two months ago. The experiments were on the estimation of linear distances and vertical angles, and involved over 1,500 observations by 128 students. The students were required to record their estimates of the length, width and thickness of a board, and of the magnitude of certain vertical angles, estimating the angles in degrees and also in ratio of vertical to horizontal. The results showed: (1) That about 60% of the estimates of length were too great, and the average error of any individual was always positive; (2) that about 80% of the degree estimates and about 60% of the ratio estimates of angles were too large; (3) that estimates of vertical angles by the ratio method were more precise than those by degrees; and (4) that the influence of training was apparent, since estimates by freshmen gave much higher errors than those by sophomores or members of higher classes.

PERSONALS.

Mr. Leslie I. Johnstone has been appointed Assistant City Engineer of St. Cloud, Minn.

Mr. H. C. Phillips has been appointed Chief Engineer of the Coast Lines of the Atchison, Topeka & Santa Fe Ry., succeeding the late R. B. Burns.

Mr. W. A. McDowell, Assistant Engineer of the Lexington & Eastern Ry., has been appointed General Manager to succeed J. Rogers Barr, deceased.

Mr. Louis L. Tribus, M. Am. Soc. C. E., Commissioner of Public Works for the Borough of Richmond, and consulting member of the firm of Tribus & Massa, has

Mr. Theodore Ensel, Secretary to General Manager Cotter, of the Pere Marquette R. R., has been made Superintendent of the Grand Rapids Division of that road.

Mr. F. H. Van Craenenbroeck has been appointed Division Engineer of the White River Division of the St. Louis, Iron Mountain & Southern Ry., to succeed Mr. W. R. Journey, resigned.

Mr. Geo. Hutchinson, formerly Superintendent of Construction of the Lackawanna Steel Co., at Buffalo, N. Y., has accepted a position with the Tennessee Coal, Iron & R. R. Co., of Ensley, Ala.

Mr. Thos. W. Cothran, Assoc. M. Am. Soc. C. E., has been appointed Principal Assistant Engineer of the Raleigh & Pimlico Sound R. R. and the Virginia & Carolina Coast R. R., with headquarters at Raleigh, N. C.

Mr. H. S. Crocker, M. Am. Soc. C. E., Assistant Manager of the Western Division Erecting Department of the American Bridge Co., has resigned his position to become Bridge Engineer of the Denver City Tramway Co., with headquarters at Room 812, Majestic Bldg., Denver, Colo.

Mr. Wm. Artingstall has been appointed [illegible] Assistant Engineer of the Chicago Union Tra[illegible] Co. in charge of lowering the LaSalle, Washington[illegible] Van Buren Sts. tunnels. His headquarters are [illegible] West Washington St., Chicago, Ill.

[illegible] been appointed Consulting Engineer to the [illegible]sident of the Borough of Richmond. He will, however, [illegible]ntinue to act as advisory head of the Presidential [illegible]us of Highways, Sewers, Street Cleaning, Public [illegible]dings and Offices, and Construction and Topograp[illegible] Engineering.

Mr. James Dun, M. Am. Soc. C. E., who ha[illegible] some years been Chief Engineer of the Atchison, [illegible]ka & Santa Fe Ry. System, has been made Consu[illegible] Engineer. Mr. W. B. Storey, Jr., Chief Engin[illegible] of the Atchison, Topeka & Santa Fe Ry., has been [illegible] Chief Engineer of the entire system, and is succeed[illegible] Mr. C. A. Morse.

Obituary.

J. C. Morse, a past president of the Illinois [illegible] Co., died at Cleveland, Ohio, Aug. 22.

James M. Malloy, head of the firm of James [illegible]loy & Co., of New York City, Contractors, died at his home in Wilmington, Del., Aug. 25, of diabetes, aged 63 years.

Timothy O'Shea, President of the O'Shea Fireproof Construction Co., died of heart failure on a Union Pacific train near Omaha, Neb., Aug. 19. He was 71 years of age.

ENGINEERING SOCIETIES.

COMING MEETINGS.

THE NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 12-14. Annual Convention at Fabyan House, White Mountains, N. H. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC WORKS ASSOCIATION.
Sept. 14-15. Second Annual Meeting at Atlanta, Ga. Secy., W. H. Flint, Chattanooga, Tenn.

LEAGUE OF AMERICAN MUNICIPALITIES.
Sept. 26 to 28. Annual convention at Chicago, Ill. Secy., Jno. MacVicar, Des Moines, Iowa.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 2 to 5. Annual Meeting at Birmingham, Ala. Secy., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 15 to 19. Annual Convention at Columbus, Ohio. Secy., Bernard V. Swenson, 60 Wall St., New York City.

AMERICAN PUBLIC WORKS ASSOCIATION.—The second annual convention of the association will be held at Atlanta, Ga., Sept. 14-15. Among the papers to be read are the following: "Surety Bonds," Fair Dodd; "Engineering Fees," Chas. C. Wilson; "Contracts as a Whole," R. C. Huston; "Standardization of Hydrant Nozzles," W. H. Hume; "Reduction of Fire Insurance Premiums," W. F. Wilcox; "Legal Pitfalls," William B. King; "Leadite," George McKay; "Cost-Plus-Fixed-Sum-Contracts," Frank B. Gilbreth. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.—The annual convention will be held at Columbus, Ohio, Oct. 15 to 19, inclusive. The meetings will be held at the Ohio State Fair Grounds, where suitable halls are available, while hotel headquarters will be at the "Southern." Delegates and guests of the association, together with those of the affiliated associations, will register and receive badges at the association booth, which will be located at the entrance of the exhibition halls on the State Fair Grounds. The day and time at which the different associations will hold their meetings are as follows: Monday morning and afternoon, Oct. 15, Claim Agents', Engineering; Tuesday morning and afternoon, Accountants', Claim Agents', Engineering; Wednesday morning, Street and Interurban Railway, joint session of all associations; Wednesday afternoon, Street and Interurban Railway, Accountants', Claim Agents', Engineering; Thursday morning and afternoon, Street and Interurban Railway, Accountants'; Friday morning and afternoon, Street and Interurban Railway.

All standing and special committees will present their reports at this convention. Some of the more important papers to be read are: "Elevated Railway and Their Bearing on Heavy Electric Traction," H. M. Brinckerhoff; "Electric Railways in Sparsely Settled Communities," E. P. Roberts; "Interurban Limited Trains," Harris P. Clegg; "Interurban Freight and Express," E. C. Spring; "Some Distinctions Between City, Suburban, Interurban and Railroad Traffic," Theo. Stebbins. In addition to the papers to be read before the Street and Interurban Railway Association, papers relating to the work of the affiliated associations will be presented before the respective associations. The entertainment feature of the convention will include a banquet, a theater party, etc. Secy., Mr. Bernard V. Swenson, 60 Wall St., New York City.

Vol. I.

LEADING

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